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THE TENUITY OF THE SUN'S SURROUNDINGS.

By E. WALTER MAUNDER, *Sec. R.A.S., Superintendent of the Physical Department, Royal Observatory, Greenwich.*

IN trying to frame a satisfactory theory as to the condition of the sun, we meet a two-fold difficulty; we have so few facts to go upon, and yet, few as they are, it is difficult so to keep them before us as to give them their proper weight.

No fact is better known than that of the great distance of the sun from us, but how easy it is to forget the necessary consequence, viz., that the smallest portion of the sun's surface visible by us as a separate entity, even as a mathematical point, is yet really a widely extended area. We habitually use somewhat small apertures to observe the sun, or we cut down our object glasses by diaphragms in order to diminish the heat and glare. We therefore lessen the resolving power of the telescope, and as we are usually forced to content ourselves with low powers on account of the unsteadiness of the air during the daytime, the practical separating power of the telescope when used on the sun is of a lower order than it is under the best conditions upon stars. Bearing in mind, then, that a second of arc on the sun represents four hundred and fifty-five miles, it follows that an object one hundred and fifty miles in diameter is about the *minimum visibile* even as a mere mathematical point, and that anything that is sufficiently large to give the slightest impression of shape and extension of surface must have an area of at least a quarter of a million square miles; ordinarily speaking, we shall not gather much information about any object that covers less than a million.

Now this fact has an important bearing on some of our theories. We easily fall into the mistake of supposing that the most delicate details which we can see really form the ultimate structure of the solar surface; but it is not possible that they can do so. The finest granule, the smallest pore, as we see it, is only the integration of a vast aggregation of details far too delicate for us to detect; and the minute speck of brighter or duller material may, and probably does, contain within itself a wide range of brilliancy, not to speak of varieties of temperature, of pressure, of motion, and of chemical constitution.

This is the case when we are concerned with areas upon the solar disc; it is much more serious when we are dealing with sections of the sun's atmosphere—if the term "atmosphere" may be allowed—at and beyond the limb. The chromosphere, some eight seconds in depth, looks a narrow enough tire to the solar wheel, but its vertical depth is three thousand six hundred miles. We think of it as a homogeneous whole; but if the chromosphere be actually—as it appears to be, and as it has generally been regarded as being—a true solar statical atmosphere, an atmosphere of heated hydrogen, just as our own atmosphere is one of cool nitrogen and oxygen, how vast the range of varying conditions which are summed up to us in the smallest point that we can perceive of it. We know how in the case of our own atmosphere the pressure is reduced to one-half at a height of three and a half miles, to one-fourth at seven miles, to one-eighth at ten and a half miles, and so on. But the force of gravity at the surface of the sun is so much greater than at the surface of the earth, that, other things being equal, the density would double by a descent of a single furlong, and five miles would take us from a level where the density was only one hundred millionth of an atmosphere to where it exceeded that of solid platinum. And from the outside of the chromosphere to the level of the photosphere would involve a range, not seven hundred times as great as this, that is to say, in the proportion of the range from unity to seven hundred times a million million, but a range from unity to a million million to the seven hundredth power!

Of course it is clear that this is not a conceivable state of things, and the most natural course is to suppose that the heat of the sun is so great as to counteract the effect of the pressure of the upper layers of the atmosphere, and to render the unit of height something very different to that given above. Thus a temperature of 35,000° C. would suffice to bring us from a density of one hundred millionth of an atmosphere at the upper level of the chromosphere to a density no greater than that of mercury (at 0° C.) at its base.

This difference is, however, far too great a one to be accepted; but adopting it for the moment, what I wish to point out is the circumstance that the thin red circle of the chromosphere, which appears to us to be so truly homogeneous except at its upper surface, which seems to be a mere narrow line, scarcely to be called a band, would embrace atmospheric densities ranging over the whole of these tremendous differences. On the outside a density of only the one hundred millionth of an atmosphere; close to the sun a density equal to that of mercury. Yet we look at it and think about it as if it were substantially the same in character throughout.

Further, close to the apparent limb of the sun we get all these varying densities superimposed. We see the centre of the solar disc through a depth of three thousand six hundred miles of chromosphere; we see the limb

through a depth of sixty thousand miles. When we pass beyond the limb we look through one hundred and twenty thousand miles of chromosphere, and every minutest point of light from the chromospheric region just outside the limb is the summation of every variety of density, from the rarest upper layers to the densest which rest on the photosphere itself. Indeed, since the chromospheric light which comes to us from close to the limb comes not only from the lowest but also from the highest strata, we might even assume that only the highest stratum had any real existence. A thin hollow shell, everywhere removed three thousand six hundred miles from the photosphere, would still *appear* to spring from the limb.

This fact, that it is the sum of a great number of superposed strata which are represented by a single point at the sun's limb, has a yet wider application. At the lowest stratum of the chromosphere we get the region of metallic vapours, which by their absorption give rise to the Fraunhofer lines of the solar spectrum, "the reversing layer," as it is commonly called. Above the chromosphere we get a region yielding faint lines of hydrogen, seen only during total eclipses. Above this we get the corona, properly so called, and above the corona we get those vast filmy extensions which Newcomb was able to trace to twelve solar diameters from the limb. We look through all of these whenever we scrutinize the sun's surface, and we see, not only that surface itself, but the integration of everything between us and it—reversing layer, chromosphere, prominences, cool hydrogen, corona, and streamers, and if there be anything beyond them, it too adds its quota to the general total. Yet, so little do these appear to be present, so little do they affect the distinctness of our view, that it requires a very distinct mental effort to realize, as we look at the chromosphere beyond the limb, that precisely the same layer lies over every point of the general disc. We have only to bear in mind the dimming and distorting effect of our own atmosphere, which, after all, in its total depth is only equal to five miles of air at the standard sea-level pressure, to be quite sure that all these various appendages have very little substance in them after all, or it would be far more difficult to photograph the solar spots and mottling than it is to map out the seas and continents of Venus.

Indeed, it is not impossible that the amount of atmosphere above every square foot of surface of that planet may be actually greater than over a similar area of the sun. Glancing down the solar spectrum, we have no difficulty at all in picking out which are the densest and blackest groups of lines. Except for the two giants H and K—which stand, like Jachin and Boaz, at the gate from the visible to the invisible spectrum—and the probably fortuitous crowding of lines at G, the most prominent groups are those of oxygen, A, B, and α, or, in wet weather, the aqueous bands. In other words, the bands due to the influence of our own atmosphere rival or exceed those proper to the sun.

Just above I suggested, by way of illustration, a density for the chromosphere at its base equal to that of mercury, and at its summit of one hundred millionth of an atmosphere. Both these are inadmissible. The Fraunhofer lines of hydrogen are so narrow and sharp—F showing only a slight fringe—that we are certain they can only be produced at low pressure. One hundredth of an atmosphere would probably not be far from the mark, that is to say, about one millionth the density of mercury. But, on the other hand, the upper surface of the chromosphere is far too distinct, definite, and brilliant for so great a rarity as the hundred millionth of an atmosphere to represent its condition there. There are, then, only two alternatives; the one to assume a far higher temperature for the chromosphere than 35,000° C.—an assumption quite inadmissible on our present knowledge, for as we regard the photosphere as a condensation surface we are unable to adopt a temperature for it that would render carbon and silicon permanent gases—the other to adopt Mr. Ranyard's contention that we have not to do with a statical atmosphere in the chromosphere, but with molecules of hydrogen moving in free paths. We should probably require a temperature of fully 140,000° C. to give us a statical atmosphere, the base and surface densities of which would, in the least, fit in with the observed facts of the case. And the total amount of gas above every square foot of the solar surface would only be about five and a half times that above the same unit on the earth.

Outside the chromosphere we meet with a region of less brilliant hydrogen some seven minutes in depth. If the idea of a chromospheric atmosphere must be rejected, much more must we reject that of a coronal atmosphere. In any case even two hundred thousand miles depth of hydrogen fails to produce absorption lines in the solar atmosphere to surpass those which our own shallow envelope can produce. We may accept it as certain that the extensions which lie above this inner corona are much more attenuated, and that to find an adequate comparison for them we must not refer to mists or fogs, but to the unsubstantial phenomena of cometary tails and streamers. To speak, as some have done, of the corona as if it were an important part of the sun, and therefore to regard the solar diameter as amounting in reality to so many millions of miles, is about as absurd as it would be to regard the edge of a Channel fog as the veritable coast-line of England.

Apart from the failure of the corona to give any substantial evidence of its existence by selective absorption, or by any markings which we can distinctly recognize as coronal when seen projected on the disc of the sun, the fact of the low density of the sun as a whole is a strong argument against ascribing any appreciable density to its surroundings. Its mean density is but one quarter of that of the earth, even if we suppose that it is entirely comprised within the photosphere; or to put it another and better way, only about one thousand one hundred times that of air. If, then, we imagine the corona and chromosphere to contain any great amount of matter—above all, if we imagine a real solar atmosphere extending some considerable distance above the photosphere—we lower the mean density of the part of the sun below that level, and at the same time, by thus setting up an appreciable surface pressure, we render it more difficult to understand how it is that, with the enormous solar gravity and a radius of four hundred and thirty thousand miles, the mean density does not exceed what we are able very easily to produce in our terrestrial laboratories.

If the amount of matter above every square foot of the solar photosphere were equal to that above the same unit of the earth's surface, then the total mass of the sun's surroundings would bear one twenty-seventh of the ratio to the mass of the sun that our atmosphere does to the earth. Probably this is under the mark, but on the other hand, we can scarcely suppose there is twenty-seven times the amount of matter to the unit of surface, as this would render the reversing layer and the chromosphere far denser than we can imagine. On the whole, then, the entire system of the sun's appendages, chromosphere, prominences, corona, and streamers, probably do not form so important a part of the sun, so far as their total mass is concerned, as our atmosphere does of our own world; whilst they are, relatively, distributed over a much greater extent of space.

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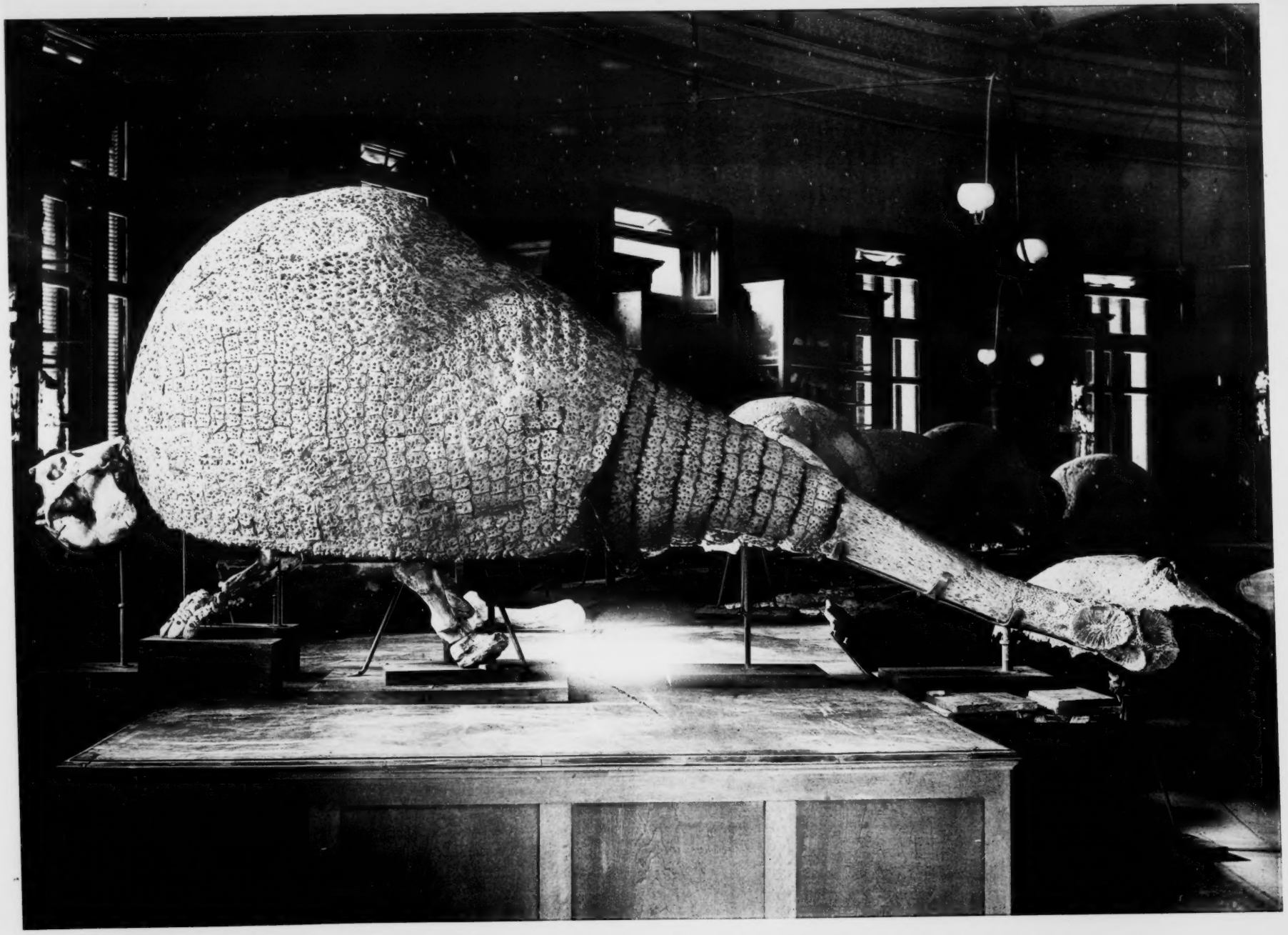

THE SKULL, LIMB-BONES, AND EXTERNAL ARMOUR OF THE CLUB-TAILED GLYPTODONT. About one-fifteenth the size of nature.

From a photograph taken in the Museum of La Plata. During life the animal was covered with a sparse coating of bristles, which came through the holes in the plates of the carapace, and seem to have been as thick as a porcupine's quill, while they were probably several inches in length. The oval, depressed, rough discs at the end of the tail carried, during the existence of this Glyptodont, huge horns, probably very like those of an African Rhinoceros. Just behind the extremity of the tail is seen the carapace of another Glyptodont with a crater-like aperture over the region of the pelvis; while still further in the background

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THE MAILED MONSTERS OF ARGENTINA.

By R. Lydekker, B.A.Cantab.

AMONG all the extinct mammals of the Argentine, none strike the beholder with more astonishment than those gigantic cousins of the modern armadillos of South America, collectively known as glyptodonts ; their name being derived from the peculiar sculpture with which the grinding surfaces of their molar teeth are ornamented. In a previous article, entitled "Armadillos and Aard-Varks," we have already considered the leading characters of the great or der of edentate mammals, of which the whole of the typical representatives are characteristic of South America, although a few of the extinct species however, the armadillos (exclusive of the aberrant pichiciago, described in the article referred to) have a larger or smaller portion of the middle region of the carapace formed of movable transverse bands of plates, in the glyptodonts the whole structure is welded into a single piece. It must not, however, be supposed that this carapace consists of a single solid dome of bone, as, if it did, there would, of course, be no possibility of growth. On the contrary, the carapace, as shown in the beautiful figure taken from a photograph of the external skeleton of the largest member of the group preserved in the museum at La Plata, is composed of a number of polygonal or rhomboidal plates articulating together at their edges, and thus allowing of free growth. In very old individuals a considerable number of these plates may, however, become completely fused together. During life these bony plates

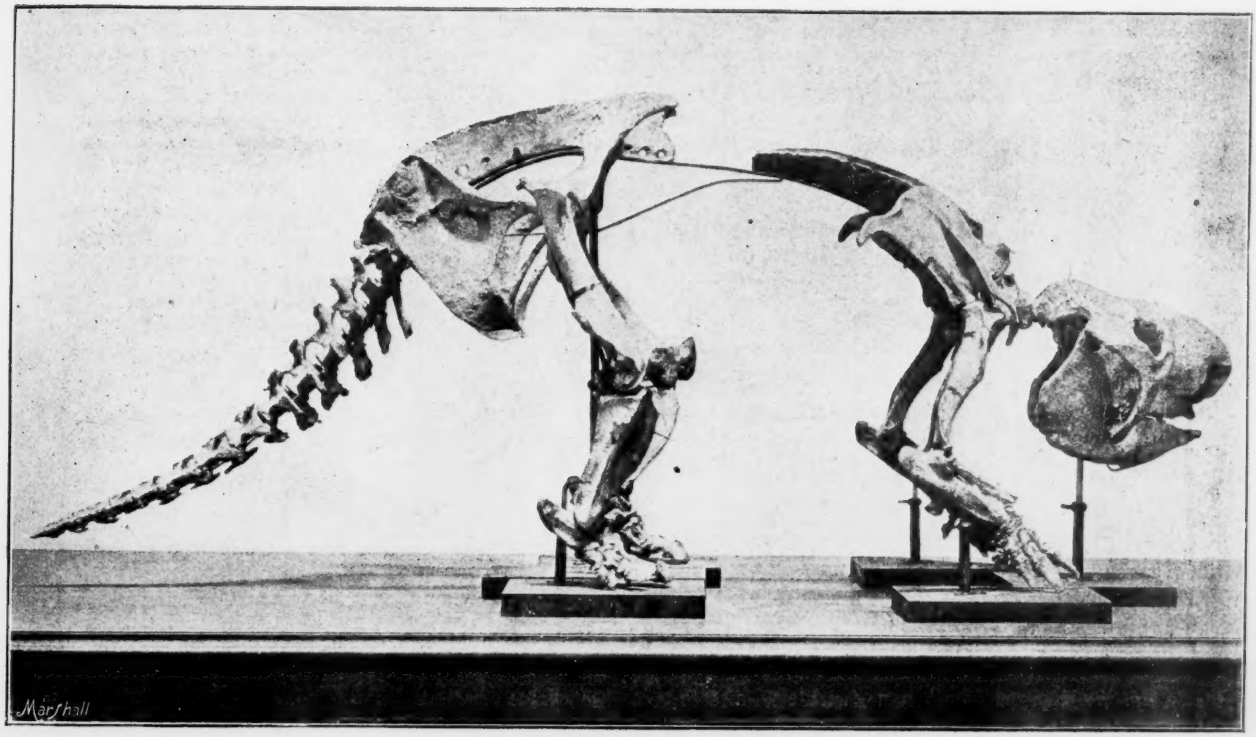

Fig. 1.—Internal Skeleton of the Smooth-tailed Glyptodont.

wandered into North America during the Pleistocene period. We have likewise pointed out how the armadillos and their allies differ from the other members of the order, and have likewise made some mention of the glyptodonts themselves. There are, however, such great differences between the various kinds of glyptodonts, which are subdivided into several genera, that the group will well repay special investigation ; and, indeed, no adequate conception of the extinct fauna of the "Land of Skeletons" could be given without devoting a separate article to these most curious animals.

As we have already pointed out elsewhere, both armadillos and glyptodonts differ from the other members of the order to which they belong in having their bodies protected by a bony shell or carapace, covering all but the under parts ; the top of the head being covered by a similar bony shield, while the tail is encased in a series of bony rings, or in rings at the base and a long tube at the tip. Whereas, were covered with small horny shields, as in the living armadillos ; and they frequently show incised lines formed by the lines of union between such shields. For instance, in the members of the typical genus of the group, or ring-tailed glyptodonts, each bony plate was smooth and polygonal in shape, while the lines indicating the borders of the horny shields take the form of a rosette. Another important point of difference from the armadillos is to be found in the contour of the skull, which is short, deep, and rounded, instead of being long, flattened, and pointed at the muzzle. Then again, whereas the armadillos have small cylindrical teeth, those of the glyptodonts are large, and fluted at the sides, with their grinding surfaces marked by the aforesaid sculpture ; while the whole series is in close contact, and forms one of the most efficient grinding machines imaginable. To support the enormous weight of the carapace, which in some of the larger kinds is considerably more than an inch in thickness, special

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modifications are needed in the internal skeleton. Here we find, for instance, as shown in the foregoing figure, that nearly the whole of the vertebræ are welded together, so that a large portion of the back-bone forms a continuous solid tube. The vertebræ of the neck are also very short, and may be partially united, so that the movements of the head must have been somewhat limited. The reader will not fail to notice also the great strength and upright position of the haunch-bones, and the powerful build of the legs and feet; the latter terminating in five toes, armed with broad flattened nails. As an illustration of the various modifications of the same general plan of structure in use in the animal kingdom, it may be well to point out how essentially the arrangement of the armour of a glyptodont differs from that of an ordinary tortoise or turtle. In the latter the carapace is completely welded to the ribs, which are situated externally to the haunch and shoulder bones; whereas in a glyptodont there is no sort of connection between the carapace and the ribs, while the latter are internal to the haunch and shoulder bones. In these respects the leathery turtle holds a somewhat intermediate position between ordinary turtles and the glyptodonts, the carapace being composed of polygonal plates totally unconnected with the ribs, while the latter are situated externally to the bones of the shoulder and haunch.

Not less remarkable are the modifications of the vertebræ of the tail for the support of the rings or tube with which the latter is encased. In the first place, most of the vertebræ of this region are welded together so as to form a hollow tapering rod; while from each segment are given off radiating processes upon which the bony plates are borne, and as the whole of the latter are firmly welded together, the entire structure is of great strength.

When standing with the edges of its impenetrable carapace resting on the ground, its mail-crowned head partially withdrawn within the front aperture of its shell, and only the lower portions of the limbs exposed, a glyptodont must have been safe from all foes save savage man, and even he must have had a tough job to slaughter the monster, if indeed he ever succeeded in doing so. That man did exist with the later glyptodonts, or those which flourished during the deposition of the Pampean mud, is, however, proved by more than one kind of evidence. For instance, crude drawings of these animals have been found incised on some of the rock-surfaces of Patagonia, while in other cases human implements have been disinterred side by side with the bones and shells. Probably the empty carapaces of the larger members of the group were employed by the primitive inhabitants of Argentina as huts, and it is said that they are sometimes even so used at the present day by the Indians. That these animals were not killed off by any living foe—either human or otherwise—may be taken for granted; and we must therefore conclude that this result was probably due to the unknown causes alluded to in the first of this series of articles as having brought about the extermination of the larger Argentine mammals. It may be well to mention that although some of the living armadillos are carnivorous, it is perfectly evident from the structure of their teeth that all the glyptodonts subsisted exclusively on a vegetable diet.

The earliest known representatives of the group occur in the older Tertiary beds of Patagonia, and may be designated pigmy glyptodonts, although they have received the uncouth name of *Propalæhoplophorus*. These creatures, which lived side by side with armadillos nearly akin to existing forms, were the dwarfs of their race, the carapace not being more than a couple of feet in length. The plates of the carapace were smooth and ornamented with a rosette-like sculpture, of which the central ring in the fore part of the shell was raised into a prominent boss. In the form of these plates, as well as in the circumstance that the tail was surrounded from base to tip with a series of knobbed rings, these pigmy glyptodonts resembled the ring-tailed glyptodonts of the pampas, of which they may accordingly be regarded as the ancestral type. In the intermediate deposits of Monte Hermoso we meet with other glyptodonts which, while much larger than those of the Patagonian beds, were generally inferior in this respect to the giants of the Pampean; some of the species being nearly allied to the small Patagonian representatives of the group, while others belong to the same genera as those found in the pampas.

Passing on to a survey of the leading types of these creatures found in the alluvial mud of the pampas, where they occur in great numbers, we may first notice the one to which the name of glyptodont was originally applied. The carapace in this form is characterized by the polygonal plates being nearly smooth and marked by a rosette of incised lines, while those along the margin are raised into a series of bold knobs. In general contour the whole carapace forms a nearly regular oval dome, while the plates on the back of the head were knobbed and ridged. Although in the specimen first sent to England the tail of another species was unfortunately affixed to the carapace, it is now known that the armour of the tail took the form of a number of rings, gradually diminishing in diameter from the root to the tip, and severally ornamented with a series of conical knobs, thus forming a protective case against which little short of a steam hammer would have been of any avail.

Although one might have thought that these ring-tailed glyptodonts, as they may be conveniently termed, were sufficiently large and *bizarre* to have stood alone in the world, they were exceeded both in size and strangeness of form by the extraordinary creature of which the external skeleton is represented in the accompanying plate. In this stupendous monster, which measured upwards of eleven feet eight inches in a straight line, the carapace is characterized by its peculiar hump-backed form, while its margins lack the prominent knobs characterizing those of the preceding group. On closer examination it will be found that each of the component plates of the carapace, instead of being polygonal and marked by a rosette of lines, is rhomboidal and pierced by from two to five large circular holes. From the analogy of the living hairy armadillo—known in Argentina by the name of peludo, or hairy animal—it is quite evident that during life the holes in the plates of the carapace of the extinct monster, which, by the way, may be known as the "club-tailed glyptodont," or technically as *Dædicurus*, must have formed the exits of large bristles, which were equal in diameter to a cock's quill, and were doubtless many inches in length. The whole body of the animal must, therefore, have resembled a gigantic porcupine. Still more extraordinary is the conformation of the huge tail, which had a length of about five feet. At its base this appendage was encircled by about half a dozen double bony rings, nearly as large at the base as the iron hoops in the middle of an ordinary beer-barrel; their component plates being pierced by the aforesaid holes for bristles. The whole of the terminal half of the tail is formed by one continuous piece of hollow bone, which, if we exclude whales, is one of the most massive bony structures in the animal kingdom, and is almost as much as a man can lift. Starting at its base in the form of a nearly cylindrical tube, this sheath rapidly expands at the sides and becomes flattened on

the upper and lower surfaces, until at the tip it finally assumes the form of a depressed flattened club, which would have formed a most efficient weapon for a giant. Along the sides of its extremity this club is marked by a number of oval depressed discs, showing a sculptured pattern of ridges and grooves radiating from the centre, and some of them attaining a length of six or seven inches. From the structure of their sculpture it is quite evident that during life these discs must have formed the bases of huge horns projecting at right angles to the tail, which must thus have formed a veritable *chevaux-de-frise*. If, as is quite probable, these horns were as long as those of the common African rhinoceros, the tail of the dædicurus must have presented a most extraordinary appearance as it dragged on the ground behind its owner (for it is impossible to believe that any muscles could have raised such a stupendous structure). The use of these horny appendages is, however, hard indeed to divine, since the creature was amply protected by the underlying bone; and it is therefore probable that they must come under the category of ornamental appendages. Be this as it may, with its bristle-clad body and horned tail, the club-tailed glyptodont may well lay claim to the right of being the most extraordinary-looking creature that ever walked this earth during the whole duration of the Tertiary period. Another species belonging to the same genus, of which the remains are found in the Tertiary beds of Monte Hermoso, is remarkable for possessing a cone-shaped aperture in the middle of the hinder part of the carapace, of which the only conceivable use is that it acted as the point of discharge of a gland.

Nearly equal in size to the Pampean representative of the preceding genus, but distinguished markedly by the characters of the skull and the more regularly dome-like form of the carapace, is another monster from the pampas which has been described under the name of *Panochthus*. Although the plates of the carapace have the same oblong form as in the club-tailed glyptodont, they lack any perforations for bristles, and are marked by a number of patches of minute tubercles, so that this species may be spoken of as the tuberculated glyptodont. Doubtless the carapace was covered during life by thin horny shields, although the marks of these are not generally shown on the bone; and from the absence of bristles the creature must have been as smooth as the small existing mulita, or three-banded armadillo. The tail was much smaller than that of the club-tailed species, consisting at the base of a number of relatively small rings, and terminating in a tube of about a yard in length. This tube lacks, however, the terminal expansion and flattening of that of the preceding form, while the large discs with which it is

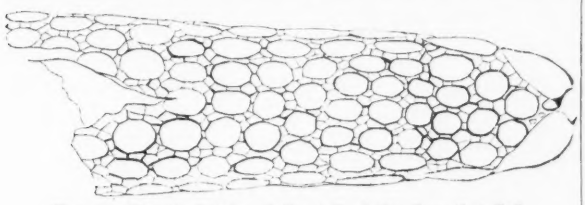


Fig. 3.—Terminal tube of the tail of the Smooth-tailed Glyptodont.

ornamented take the form of prominent rough bosses, which probably carried flattened horny knobs, instead of spines, during life.

The last representatives of the group to which we shall allude are much smaller species from the deposits of Monte Hermoso and the pampas, which may be known as the smooth-tailed glyptodonts, or technically, *Hoplophorus*. In these creatures the carapace was much more elongated and depressed than in the other kinds, while it projected forward on the sides of the shoulders in a manner somewhat like that of the armadillos. The plates of the carapace show a rosette pattern, not unlike that of the ring-tailed glyptodonts, but they are still smoother, and of an irregular oblong shape. As regards the tail, this consisted at the base of a number of smooth rings, fitting into one another at their junctions like the joints of a telescope; while at the end it terminated in a slightly flattened tube ornamented with a number of small, smooth, oval discs of about an inch in diameter, interspersed with which were arranged a few much larger but equally smooth and prominent discs along the sides. These discs of all dimensions were evidently coated with smooth scales of horn during life; and from the absence of apertures for bristles, the same smoothness doubtless characterized the carapace. The head was protected by a smooth shield of small tesselated plates; and the skull, as shown in our figure of the skeleton (Fig. 1), is characterized by the peculiar twisting and curvature of the bones of the nose.

Such are the chief characteristics of the better known representatives of the mailed monsters of Argentina—a group which was continued in a straight line from the pigmy glyptodont of Patagonia to the ring-tailed species of the pampas, while all the other giant forms of the latter must be regarded as lateral offshoots from the original stock, which continued, as is so often the case, to develop more and more *bizarre* characters until the date of their final disappearance. In conclusion, we must not omit to mention that a strange gigantic armoured creature, found commonly in the cavern deposits of Brazil, and also rarely met with in Argentina, seems to have been a kind of connecting link between the glyptodonts and the armadillos, having the carapace formed of a number of movable plates, arranged in a series of overlapping bands as in the latter, but with teeth of the type of the former. Unfortunately, however, this interesting creature, which must have been as big as a large rhinoceros, is known by such fragmentary remains that its full affinities cannot yet be determined, as we are still ignorant whether its skull approximated to the glyptodont or the armadillo type.

STINGING INSECTS.—II.

By E. A. Butler.

(*Continued from page* 43.)

AT the close of our last paper we dealt briefly with the aculeate Hymenoptera, the sole representatives of the first of the four groups into which we divided "stinging" insects, for no others possess the true vengeful sting; we may now further consider the same group. In connection with what was said of the inability of bees to withdraw their stings when they have pierced such a yielding substance as soft leather or india-rubber, a correspondent has pointed out that the same disability rests upon wasps, but that these differ from bees, so far as his experience goes, in lacking the power to tear themselves away as a bee would do, leaving the sting behind. In fact, the wasp that has ventured to employ its sting in this way is completely trapped, and the writer states that he found the only way to liberate a prisoner so detained was to cut off its sting.

The accompanying plates, which represent the stings of the hornet and honey bee, are from photographs taken by Mr. T. E. Freshwater, and lent by Messrs. Newton and Co., of Fleet Street. The original photographs were

obtained from microscopic slides, and therefore represent the objects crushed flat so as to secure suitable transparency for microscopic examination. In consequence of this crushing, the lancets in the hornet's sting have escaped from the grooved dart within which they are ordinarily concealed. But there is an advantage in this, for the backward-bent barbs at their tips have thus become very distinctly visible, and make it easy to understand the difficulty of withdrawing the sting from the wound. The two hair-beset feelers would, under natural circumstances, lie by the sides of the dart, where they serve the purpose of investigators of the surface on which the puncture is to be made. In this figure only the external part of the sting is shown, and this can be plunged into the wound as far as the point where the diameter of the dart suddenly increases. In the bee's sting, which may be compared with the figure of a wasp's sting in our last number, the lancets have retained their natural position, but their outline can be traced within the hollow dart; their long, slender ends can then be followed through the pouch-like thickening at the base of the dart until they curve round at the top and communicate with the levers, which appear as dark bars to the right of the pouch. The muscles by which this complicated mechanism is worked have been dissolved away so as to render the framework more distinct. From the head of the pouch-like enlargement, the delicate membranous tube which conveys the poison to the sting can be traced between the lancets and the levers. It leads into the poison bag, the whole of which is present and appears as a rounded body at the upper part on the right. The secreting tubes, which elaborate the poison and supply it to this receptacle, have been removed, as have also the feelers. When not in use, the whole of the apparatus shown in both these figures is withdrawn into a cavity between the terminal plates of the body, and nothing of it can be seen from the outside.

There is no doubt that a good deal of difference exists as to the readiness with which the different kinds of bees and wasps will resort to the use of the sting. Amongst the humble bees it has been noticed that the subterranean builders are far more irascible than those that construct nests above ground, and the most fiery-tempered of them all is the great red-tailed species (*Bombus lapidarius*), the big females of which will inflict a severe sting upon anyone who incautiously interferes with their quarters. Even amongst the same species, the readiness to bring the weapon into requisition varies with the temperature and other climatic circumstances, as well as with the nervous condition of the insect. That the creatures have "moods," and that these affect their pugnacity, is well shown in the record Sir John Lubbock has given of the adventures of a tame wasp he kept for nine months. It was not a true *Vespa*, nor indeed an English species at all, but a kind called *Polistes gallica*, which Sir John had obtained in the Pyrenees. He says: "I had no difficulty in inducing her to feed on my hand, but at first she was shy and nervous. She kept her sting in constant readiness; and once or twice in the train, when the railway officials came for tickets, and I was compelled to hurry her back into her bottle, she stung me slightly—I think, however, entirely from fright. Gradually she became quite used to me, and when I took her on my hand apparently expected to be fed. She even allowed me to stroke her without any appearance of fear, and for some months I never saw her sting." It is pathetic that the good mutual understanding thus established could not be prolonged into another season; but notwithstanding the greatest care taken on the human side, the rigours of the English winter proved too much for the constitution of the creature that had been born under sunnier skies. Paralysis set in, and soon the last record had to be penned, that "she could but move her tail, a last token, as I could almost fancy, of gratitude and affection."

The aculeate Hymenoptera might be roughly divided into three sections, according to the nature of the food; first, those that are purely vegetarian in diet, viz., the bees; second, those that are omnivorous, viz., the ants and social wasps; and third, those that are distinctly carnivorous, viz., the solitary wasps and fossores. It has already been pointed out that this last group are excellent hunters, whose armoury consists of jaws and sting. Some of them manifest remarkable patience and skill in the search for provisions wherewith to anticipate the wants of their expected brood; in fact, it has been suggested that there may be distinguished amongst them species that, by long use, have brought their predatory practices to such a pitch of perfection that the pursuit and conquest of their prey has almost assumed the characteristics of a fine art, while others are still comparative bunglers at the work. A numerous section of this group consists of very active insects with an abdomen which is usually red, while the rest of the body is black; they hunt down spiders, which in some cases are considerably larger and heavier than their captors. M. Ferton has recorded in the *Transactions of the Linnæan Society of Bordeaux* a number of observations which he has made upon the habits of these insects, the *Pompilidæ*, and we give below some of the most interesting cases. It should be remembered that spiders also have a supply of poison, which is poured out through their jaws, so that in all contests between them and the *Pompilidæ* the advantage is not all on one side, but there are risks to be encountered by both parties. Nevertheless, the fly, although often the smaller of the two, is usually the braver.

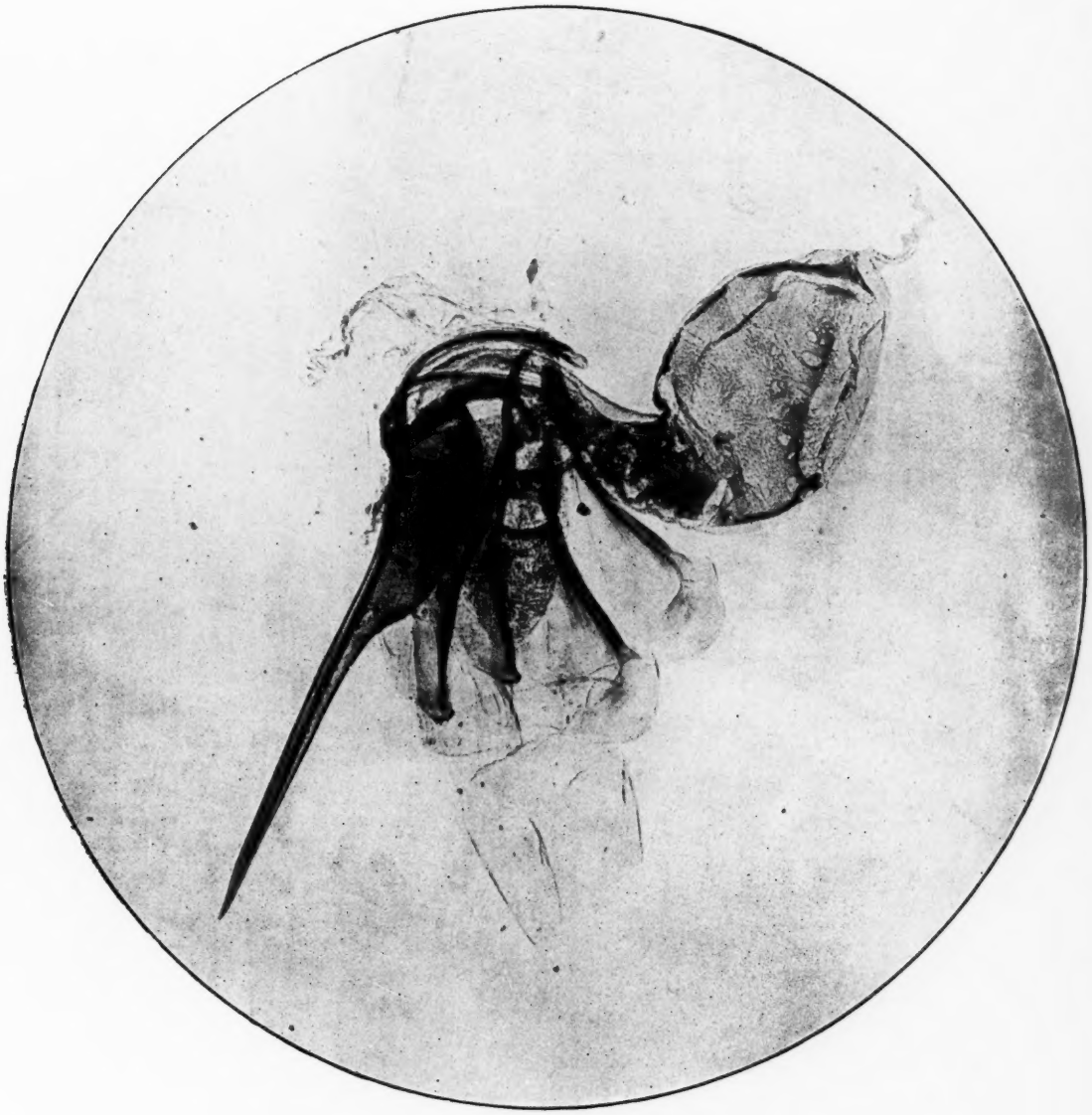
Some of these *Pompilidæ* go boldly into the lairs of those spiders that construct such abodes, instead of waiting for a chance passer by, or hunting in the open. In such cases the spider seems usually to recognize that it has met with its match, and endeavours to escape as quickly as possible. M. Ferton relates of one species, which hunts a kind of spider that lives in a burrow closed by a stone, that the fly removes the stone, boldly enters the burrow, and slays the spider, afterwards dragging out its carcase and conveying it to its own nest. In another instance a Pompilid was seen digging vigorously at an isolated tuft of grass; suddenly it ceased its exertions and a spider was seen crawling cautiously up one of the grass stalks, and trying to escape by jumping from one to the other. Immediately the wasp was after it, prudently keeping, however, at arm's length, till at last the spider, having reached the edge of the grass-tuft, and apparently recognizing that it would stand no chance on the open ground with its pursuer close behind it, gave itself up for lost, threw itself to the ground, packed its legs up close to the body, shamming death, and awaited its fate. The wasp darted down upon it and gave it a couple of stings in the most vulnerable part, and all was over. Sometimes the sting was not sufficient to kill the prey, and then the legs of the spider were often bitten off by the wasp, lest there should be undesirable struggles on the way home. M. Ferton sometimes rescued the spider after it had been stung, and endeavoured, in some cases successfully, to resuscitate it. In one instance the spider was at first quite motionless, but after two hours it began to show signs of life, and, gradually regaining its powers, was by the next day fully recovered. It was noticed that an endeavour was always made to inflict the sting in the

XUM

STING OF HORNET, showing Dart, Lancets with Barbed Tips, and Feelers.

Enlarged from a Photograph by Mr. T. E. FRESHWATER. The scale of amplification is the same as that employed for the Bee's Sting on the opposite page.

Direct Photo Co., 9, Barnsbury Park, N.



STING OF WORKER BEE, showing Dart containing Lancets, Levers, and Poison Bag.

Enlarged from a Photograph by Mr. T. E. FRESHWATER.

Direct Photo Co., 9, Barnsbury Park, N.

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centre of the under side of the prey. There is a good anatomical reason for this; in this position is placed the central mass of the nervous system, and a sting so directed as to pierce that important apparatus would no doubt at once produce paralysis, while similar wounds inflicted elsewhere would be followed by less serious results.

These are certainly marvellous facts, and indicate an amazing degree of sagacity on the part of the insect. But this is just the characteristic for which the aculeate Hymenoptera, as a body, are, above all insects, celebrated; indeed, it is in this group that insect intelligence reaches its highest grade of development. Numerous instances of similar skill and perseverance have been recorded by English observers, and especially by Mr. F. Smith, one of our earlier historians of these insects. Amongst other records may be noted some curious facts which he gives about one of our commonest fossores, *Mellinus arvensis*, a shining black-bodied insect with yellow bands (Fig. 4), which provisions its nest with various kinds of Diptera. He says: "It is amusing to see four or five females lie in wait upon a patch of cow-dung, until some luckless fly settles on it; when this happens, a cunning and gradual approach is made. A sudden attempt would not succeed, the fly is the insect of quicker flight; therefore, a degree of artifice is necessary. This is managed by running past the victim slowly, and apparently in an unconcerned manner, until the poor fly is caught unawares and carried off by the *Mellinus* to its burrow." A similar device is adopted by prettily variegated, but small, species belonging to the genus *Oxybelus*. When the first fly has been deposited, an egg is laid; the necessary number of victims are then soon secured, and the mother's task is complete. But the matter is not always so simple; there is the instability of the English climate to be reckoned with, and this may upset the calculations and multiply the anxieties of even these lowly creatures; for, as Mr. Smith adds, "sometimes she is interrupted by rainy weather, and it is some days ere she can store up the quantity required." A larva which was found feeding became full-fed in ten days; in that time it devoured the softer parts of six flies—the heads, the harder parts of the bodies, and the legs being the parts left untouched.

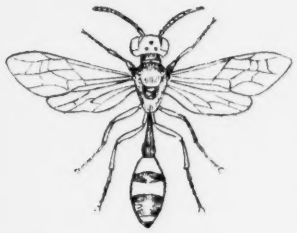


Fig. 4.—*Mellinus arvensis*. Magnified three diameters.

The same indefatigable observer, who spent many years of his life in gaining a knowledge of the habits of the aculeate Hymenoptera, records of a certain colony of a jet black fossor (*Trypoxylon figulus*) which preys upon spiders, that they had very sensibly constructed their burrows in a bank of light earth just under a hawthorn hedge which was tenanted by large numbers of small spiders; the hunters had therefore only to rush out of doors and flit up into the hedge in order to accomplish the task of provisioning with the least possible expenditure of time and energy. When the prey is small and gregarious, it will be captured in a wholesale manner; thus Mr. Smith states of another black species (*Pemphredon lugubris*), that he has seen the female "settle on a rose-tree, and scraping a number of aphides into a ball, fly off with it, carrying it in front of its anterior legs and under its head." One of our largest and most local species (*Philanthus triangulum*), a black and yellow insect, actually preys upon bees, using whatever kinds happen to be most abundant in the neighbourhood of its nest, but showing a preference for the hive bee. It is a bold-looking creature, but very slow to use its sting upon human kind, although it has no difficulty in overpowering the bees that constitute its prey. These it catches by lying in wait amongst the flowers they frequent, and pouncing on them as they are intent on gathering honey. Seizing the bee with its jaws between head and thorax, it at once inflicts a sting in the abdomen and thus renders its victim powerless; then grasping it tight with jaws and legs, it flies off with its burden to its nest.

One of the most curious of the solitary wasps is that called *Eumenes coarctata*. Like the rest of its tribe, it is black, with yellow bands, but it may be at once distinguished by the long, thin stalk that attaches the strongly pear-shaped abdomen to the thorax. This curious insect constructs little globular cells of mud on the stalks of heath plants. Each cell is the residence of one larva only, and is provisioned with small caterpillars. Others of the solitary wasps, belonging to the genus *Odynerus*, burrow into banks, and arrange at the entrance of the burrow a sort of cylindrical vestibule, made of fragments of the surrounding soil; it thus appears as a tube projecting from the mouth of the burrow, and curving downwards (Fig. 5). If the burrow be traced to its end, cells will be reached, which, when opened, display piles of half-dead caterpillars stored up for the young. Mr. T. R. Billups once found a colony of one of these insects at Chertsey, the entrance tubes of which were about an inch and a half long. On opening one of the cells he found a truly bountiful provision, testifying to great industry on the part of the collector; as many as thirty-three small caterpillars of moths, and four of saw-flies, all reduced to a semi-animate condition by the stings they had received, composed the lavish stock of this little larder.

Fig. 5.—Tubular entrance to nest of *Odynerus*.

Notwithstanding their stings, the fossorial Hymenoptera and solitary wasps have to suffer much at the hands of parasites; ichneumon flies, golden wasps, and a set of dipterous flies (*Tachinidæ*), shaped rather like blue-bottles, make more or less havoc amongst their larvæ. Mr. J. E. Fletcher records having found in a damaged willow tree a pile of small cocoons crowded together in a small space. From a portion of this pile which he took home he bred twenty-seven examples of a black fossor (*Crabro leucostoma*), together with an ichneumon fly and a dipterous fly belonging to the above family. As the cells of the *Crabro* had been provisioned with small and delicate long-legged flies, of a family quite distinct from that of the parasites, the relics of four different kinds of insects had thus become associated in one spot, thereby affording to anyone who might find the collection after the insects had deserted it, an interesting zoological puzzle to determine the mutual relations of the different members of the company. Such associations of heterogeneous remains are sometimes brought about by the practice that some of these insects adopt of taking possession of the abandoned burrows of other insects, instead of putting themselves to the trouble of excavating their own. Thus Mr. Douglas records having found examples of the above-named *Trypoxylon* in the burrows of one of the bark-boring beetles we recently described. Spiders had been stored in the burrows as food, and one of the golden wasps was also present as a parasite upon the *Trypoxylon*. But in addition to these, another species of *Trypoxylon* had also made its

home there, as well as a little solitary bee; so that in this one spot there were evidences, in one way or other, of the presence of no less than half a dozen different sorts of creatures, an association in large degree accidental, but still full of perplexing complications to anyone who was not familiar with the habits of the different members.

It is not always abandoned burrows that are thus appropriated by indolent excavators; sometimes burrows that have just been made by one species will be captured by another, though it usually requires some diligence and perseverance, as well as courage, to retain possession of a site thus surreptitiously gained. For example, a *Trypoxylon* was found frequenting the holes in a post which had been pre-occupied by one of the solitary wasps of the genus *Odynerus*. The little black invader had begun to lay in a stock of provisions in the shape of a small round ball containing about fifty aphides. The legitimate proprietor of the burrow, on her return, seized the pellet, and, flying out with it held between her legs, dropped it about a foot away from the entrance. The *Trypoxylon* again picked up her luggage and replaced it, but on the return of the wasp it was again turned out, and this continued several times, till, the wasp being absent longer than usual, the *Trypoxylon* had time not only to replace the obnoxious parcel, but also to cement up the entrance of the burrow. The *Odynerus* was thus checkmated, for though she repeatedly returned to the spot, she made no attempt to force an entrance through the barricade, but finally departed in search of more peaceful quarters.

We must now pass to the second of our groups of stingers, which comprises such other hymenopterous insects as are able to prick the skin, but not to make a painful wound, since no poison accompanies the puncture, and the effects are of the most transient description. Under this head come only certain members of the great group of ichneumon flies, and we may therefore dismiss them with but a brief notice. As before, it is only the females that possess the boring implement. Its structure is, in general plan, similar to that of the sting of bees and wasps, but there is no poison gland. There are two side pieces which act as a sheath, and a central barbed borer. The purpose of the instrument is, in general, to pierce the bodies of insects so that eggs may be inserted beneath the skin, for the ichneumon flies are, in their early stages, internal parasites, and their larvæ, which are fat maggots, devour the contents of the bodies of their hosts, in such a way, however, that no vital parts are touched till there ceases to be any necessity to prolong the life of the doomed victim.

The boring weapon is usually more or less visible outside the body, and is sometimes extremely long. A very long ovipositor usually implies that the host lives in rather inaccessible places, which the ichneumon itself cannot reach, as is the case, for example, with those insects that inhabit tunnels which they have excavated in the trunks of trees. In such cases the ovipositor can be passed in at openings which are too small to admit the body of the ichneumon itself, or it may even make an entrance for itself by being worked through the wood. The prey can thus be reached, and the eggs deposited in the proper situation. Even in English species this boring and egg-laying machine may be much longer than the body; one is now before me in which the body is half an inch long, while the ovipositor extends for nearly an inch beyond this. But from Japan comes the record of a species of Braconidæ which has the body three-quarters of an inch long, while the boring weapon attains the extraordinary length of six and three-quarter inches! The ichneumons with long ovipositors are not the ones to use them on human kind; the instrument is too flexible and too blunt to be used with any effect on the human skin. But some of the larger kinds that have very short ovipositors can give a sharp prick, which causes one to drop them immediately under the impression that a real sting has been received. However, the sensation is only momentary, and no lasting effect is produced.

(To be continued.)

THE SACRED WATER OF MECCA.

By C. A. Mitchell, B.A.Oxon.

THROUGH the kindness of Lady Burton, I have been enabled to make an analysis of some of the water which the late Sir Richard Burton, disguised as a pilgrim dervish, brought back from Mecca in 1853.

The Zem-Zem Well, according to tradition, is the Well of Hagar, and is used for no other purpose than drinking and religious ablution. Each pilgrim to Mecca is anxious to drink and bathe in the water, but as there is not sufficient for all, the following device is adopted:—One Arab, standing on the wall of the well, draws the water up and pours it over the pilgrims as, stripped to the waist, they advance in turn. As it pours over him each drinks what he can, and the remainder runs down, soaking through the loin-cloth, back into the well, to be used again on succeeding pilgrims. If this practice has been continued day after day and year after year, it is not surprising to find that the water is very rich in chlorides, and that it contains a large quantity of solid matter in solution.

Sir Richard Burton described the water as extremely nauseous in its taste, and resembling a strong dose of Epsom salts. This observation is borne out by the analysis, which shows that magnesium sulphate (Epsom salts) is an important constituent. Its use is said to produce boils and other unpleasant results, and should the well happen to become infected with cholera germs, a far-reaching epidemic is the probable result. Large quantities of the water are exported from Mecca to other Mahommedan countries, and those who drink it are believed to acquire the facility of speedily learning Arabic.

The sample analyzed was contained in two small tin bottles which were hermetically sealed, and which had remained untouched since they were brought from Mecca. Together they contained about half a pint of the water. On opening them there was a slight evolution of gas, and the water within was found to contain a quantity of beautiful silky crystals in suspension, and a few earthy particles settled at the bottom. On examination these minute crystals proved to be a compound of tin, which had been formed by the long-continued action of the water on the interior of the tin bottles. These foreign matters being filtered off, there was left a clear colourless liquid with a slight smell, which was more perceptible on warming. No trace of tin could be found dissolved in the water.

In judging as to the fitness of a water for ordinary use, the chief points to be determined are the amount of solid matter left on evaporating a certain definite quantity, the amount of chlorine present in solution, the hardness, and the amount of free ammonia and ammonia in combination with animal or vegetable matter (*i.e.*, albuminoid ammonia).

As a general rule, waters which contain less than forty grains per gallon of solid matter in solution are not condemned if the other points are satisfactory. The method of determining this solid residue is to evaporate a definite quantity of the water in a platinum dish, and to

weigh the residue, from which result the amount per gallon is calculated. The amount of solid residue left on thus evaporating some of the Zem-Zem water corresponded to two hundred and nineteen grains per gallon—a quantity characteristic of a strongly saline water.

Since chlorine (in combination with sodium as common salt) is one of the substances given off from the skin, its presence in water in any large quantity is an indication of probable sewage contamination. Should a water be found to contain as much as nine grains of chlorine per gallon, it would be looked upon with strong suspicion, although, if the well or spring from which it was taken should happen to be situated near a salt bed, the chlorine might be derived from that source. The amount found in the Zem-Zem water, viz., sixty-nine grains per gallon, whether derived from the soil or, as is highly probable, from the skins of the Arab pilgrims, condemned it absolutely.

The hardness was determined by a method devised by the late Dr. Clarke, and known as "Clarke's soap test." It consists in adding a solution of pure soap, of which the strength is known, to the water, until a permanent lather is produced. Each successive portion of soap solution added corresponds to a definite quantity of carbonate of lime, or its equivalent of other salts, dissolved in the water. As no lather can be produced until the soap has neutralized the whole of the lime or magnesia in the water, we can estimate very rapidly the hardness in this way. This is usually expressed in degrees, each of which corresponds to one grain of carbonate of lime per gallon. Thus, to say a water has fifteen degrees of hardness means that it contains constituents which produce the same degree of hardness that fifteen grains of carbonate of lime per gallon would do. The Zem-Zem water had forty-three degrees of hardness—about three times that of an average water.

The quantity of albuminoid ammonia is one of the most important data in estimating a water. A good water should not contain as much as ·1 part of ammonia in a million of water. The quantity of albuminoid ammonia in the Zem-Zem water, viz., 2·2 parts in a million, was characteristic of sewage effluent, and confirmed the conclusion already arrived at from the estimation of the chlorine.

Prof. Crookshank was kind enough to make an exhaustive bacteriological examination of some of the water, but was unable to find any trace of living organisms. The water was sterile, as might well be expected after its having been hermetically sealed and in total darkness during forty years.

The following were the quantities of some of the principal constituents of the water :—

	Grains per gallon.		Grains per gallon.
Silica	3·0	Potassium ...	24·3
Aluminium ...	·8	Ammonium ...	5·3
Calcium	·5	Chlorides ...	69·3
Magnesium ...	6·6	Sulphates ...	30·7
Sodium	38·3	Nitrates ...	19·9

SEWER GAS AND ZYMOTIC DISEASE.

By A. C. Ranyard.

THE fear, amounting to terror, lest we should breathe a whiff of sewer gas, has had potent and far-reaching influences on modern life. What is known as Sanitation has increased by leaps and bounds during the last quarter of a century, until the dread of sewer air has become a factor in legislation sufficiently powerful to procure the passing of Acts of Parliament that materially modify the rights of Englishmen; and yet most of the theories of the so-called Sanitary Science have been arrived at by the deductive method, which seriously led astray the pioneers of thought when groping after the first discovered laws of the physical sciences.

Perhaps the theory which has been most fruitful in causing a lavish expenditure on sanitary appliances (the fashions of which change almost as rapidly as the fashions in feminine head-gear) is the theory that sewer gas is heavily charged with the germs of disease. It is founded on two assumptions, both of which have been received as self-evident. The first assumption is that sewage matter swarms with the germs of disease; and the second is that the micro-organisms living in sewage matter can rise into the air with the effluvia or smell from sewage, and are carried wherever the sewage smell can be detected. To the more thoughtful there seemed to be a difficulty in supposing that micro-organisms could be carried into the air by evaporation. But the difficulty was quickly met by the theorists, who suggested that bubbles of gas *must* rise from the sewage sludge, and that such bubbles on bursting would project minute globules of liquid into the air, and the minute globules might carry the dangerous micro-organisms. The theory was ingenious, it was easily understood and was widely adopted, and the logical and natural consequences of panic and legislation followed. The public is not so deficient in the power of making logical deductions as it is deficient in the critical faculty which should lead us to test by experiment the axioms we too readily accept as self-evident.

It was not till 1883 that experiments were made by M. Miguel in the Paris sewers to determine the number of micro-organisms per litre of sewer air as compared with the number of similar organisms in the air above ground. He found an average of from 0·8 to 0·9 per litre in the air of the sewer under the Rue de Rivoli, in the neighbourhood of the point where the sewer joins the large collector of the Boulevard Sébastopol; and he states that the organisms in the air of the Rue de Rivoli may in summer exceed in number the organisms in the sewer air by five or six times, whereas in winter the ratio may be reversed.

Then followed a series of investigations on the subject, undertaken by Drs. Carnelly and Haldane, who made observations in the main sewer of Westminster Palace and in various sewers in Dundee. The general results they arrived at were that—

1. The carbonic acid gas in sewer air is about twice as much, and the organic matter about three times as much, as in the outside air at the same time.

2. The number of micro-organisms is less in sewer air than in the outside air at the same time.

3. The quantity of carbonic acid, organic matter, and micro-organisms in sewer air is less than in the air of naturally ventilated schools, and, with the exception of organic matter, it is less than in the air of mechanically ventilated schools.

4. Sewer air contained a much smaller number of micro-organisms than the air in any class of house they had investigated.

During the last year and a half, Mr. J. Parry Laws has been occupied on a series of experiments made on behalf of the London County Council in the sewers of the Metropolis. The first sewer experimented upon was that known as the King's Scholars Pond sewer, which runs in a straight line under the Green Park from Piccadilly on the north to the Buckingham Palace Road on the south. It was constructed some one hundred and twenty years ago, and has therefore been in use long enough, as

Mr. Laws remarks, to become contaminated in every possible way. One important peculiarity of this sewer is that no lateral sewers or house drains enter it from one end to the other, and that it is freely ventilated to the air of the park. In length it is about three hundred yards; it is barrel-shaped, about eleven feet high and nine feet wide, and is ventilated by open gratings in the crown of the sewer. These open gratings could be closed for the purposes of experiment, and sewage matter could be poured through them at various distances from the experimenter, so as to imitate as nearly as possible the splashing and disturbing effect of matter entering a sewer from a house at a known distance. A wooden staging was erected across the sewer, near to one of the entrances, from which the experiments were made.

Mr. Laws adopted the following process for determining the number of micro-organisms in the air. A known quantity of air was aspirated through a sterile tube, containing two sterile plugs composed of powdered sugar and glass wool. These plugs, which filter the air, were, after the completion of the experiment, transferred to two circular cultivating plates covered with nutrient gelatine in a liquid state; after careful mixing with a sterilized platinum needle, the gelatine was allowed to solidify by cooling. Each organism, therefore, becomes fixed, and if capable of growing in the medium it forms a colony, which, after the lapse of four to six days, is evident to the naked eye. In almost every case the colony consists of a pure growth of one species only. These colonies were examined microscopically, and re-sown in sterile cultivating tubes, containing nutrient gelatine or agar-agar, for further study.

In a report* to the London County Council, recently issued, Mr. Laws gives a list of the micro-organisms detected by him in the air of the sewer above-mentioned as well as in the air of other sewers. All the micro-organisms tabulated by him belong to the class known as non-pathogenic—that is, they are harmless bacteria—and, with one exception, they are species commonly found in air and water.

He says: "There are two points with reference to the organisms in sewer air to which I wish to call special attention—firstly, the absence of bacillus *coli communis* and *micrococcus ureæ*, two organisms which must be present in sewage in immense numbers; secondly, the almost entire absence of any organisms capable of very rapidly liquefying gelatine, the only exceptions being the common hay bacillus (*bacillus subtilis*) and a micrococcus mentioned in my first report. In sewage, on the other hand, a large number of organisms, for the most part bacilli, possess this property of very rapidly liquefying gelatine."

In the splashing experiments conducted in the King's Scholars Pond sewer, Mr. Laws found that when the splashing was sufficiently violent to produce a very fine state of division of the sewage, organisms from the sewage were occasionally carried to a distance of from fifty to sixty yards; but, as a general rule, there is comparatively little draught in the sewers, and the particles are carried no great distance, and quickly subside again into the sewage at the bottom, or are caught on the wet walls of the sewers, and Mr. Laws found that, as a general rule, a decrease in the number of organisms in the fresh air above ground was followed by a decrease in the number of micro-organisms in the sewer air.

These experiments entirely sweep away the theory that zymotic diseases are spread by micro-organisms carried by sewer air. It may be regarded as demonstrated beyond dispute, that certain kinds of micro-organisms invariably accompany certain diseases, and reproduce similar diseases when introduced by inoculation into the bodies of men or animals, even after one or more generations of such organisms have been grown in sterilized media. So that such diseases must be produced by the micro-organism, and not by any organic matter or product of putrefactive decomposition allied to the dangerous class of poisons known as ptomaines.

But as far as infection by micro-organisms is concerned, it seems that the sewer rats have more reason to complain of our ventilating their homes with the bacteria-laden upper air than we have to complain of infection by micro-organisms carried by sewer air into our streets and houses. In a matter of such great importance, involving risks of life, and—what is even of more importance—involving the healthy condition, happiness, and working power of millions, we must proceed with all scientific caution, and must not conclude without prolonged further investigation that sewer air is not injurious. It may have an indirect effect in lowering our vital power and rendering us more liable to the attacks of micro-organisms derived from other sources.

We have at present very few accurate statistics to go upon, but general observations seem to show that the men who work in sewers are not more subject to zymotic diseases than other classes of the community—in fact, they seem to be rather less subject to them—and the children of the sewer-men, who live at the outfall works and who spend a great deal of their playtime upon the ventilating grids of the sewers, seem to be very healthy little creatures. As far as I can learn, there has been no recent outbreak of zymotic disease amongst them, while the rest of London has been passing through a long period of feverish anxiety, and the permanent hospitals and temporary fever hospitals have been crowded to overflowing with infectious patients.

I have made what inquiries I can from Mr. Laws, and others who have come into contact with workers in sewers, to find what precautions the sewer-men take before they eat their dinners. I am informed that much of their work involves the plunging of their hands into offensive-looking sludge, but it is only the more fastidious of them who carry a rag or a handful of cotton waste in their pockets, with which they give their hands a rub before they sit down to eat. The rest, perhaps, give their hands a rub on their trousers or coat, and set to work at their food at once, without carefully cleaning their nails, or washing their hands with disinfectants, as a doctor would think necessary under similar circumstances, and yet these men are comparatively healthy, and, if anything, are less subject to zymotic diseases than their neighbours. Such facts would almost lead one to doubt whether our theories as to infection by sewage, and our dread of a whiff of sewage air, may not be as mistaken as the superstitious belief of the savage in the protecting power of his amulet, or as unfounded as his terror of the evil eye.

But we must proceed cautiously if we wish to follow the scientific method, and must remember (as Mr. Charles Booth, the present President of the Statistical Society, forcibly pointed out in a very interesting address, delivered in November last, on the results of the census of 1891 with regard to the statistics of life and labour in London), that the results which the statician offers us need to be very carefully analyzed before we dare to found extensive theories upon them. To form a sure foundation for reasoning by the inductive method, we need a series of

* "Report to the Main Drainage Committee of the London County Council on Sewer Air Investigations," by J. Parry Laws, F.I.C. Steel and Jones, 4, Spring Gardens, S.W. Price 6d.

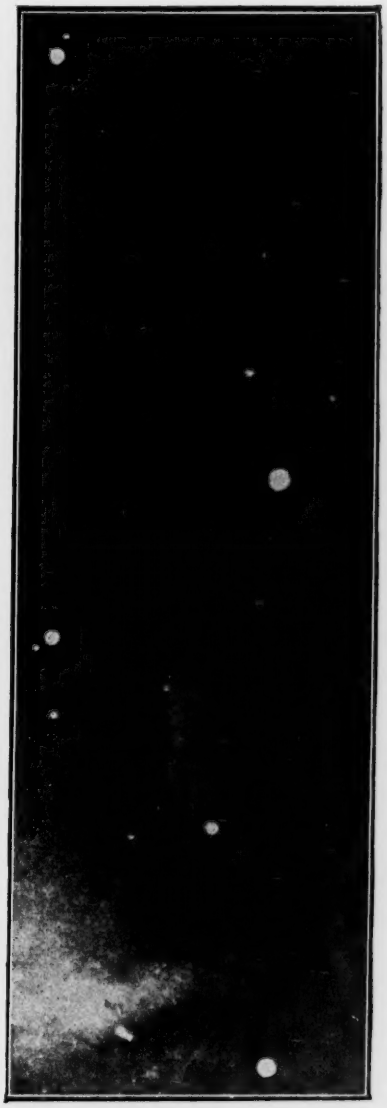
XUM

STRUCTURES ON THE EASTERN SIDE OF THE ORION NEBULA.

Both pictures have been made from negatives kindly lent by Dr. ISAAC ROBERTS.

WEST. EAST.

1.—Made from a long-exposed photograph of the Orion Nebula, showing notches on the eastern edge of great branching structure.



WEST EAST.

2.—Made from a photograph taken with a shorter exposure, showing the well-defined eastern edge of the same structure, with small and large notches.

XUM

XUM

simple experiments which can only be interpreted in one way; but the results which the statician offers us are frequently the outcome of many causes acting concurrently. It may be that sewage poison has but little effect on those who live an active and out-of-door life, while on the town-liver and the sedentary worker it produces a depressing effect, which predisposes him to the attacks of zymotic disease. It is certain that the small amount of organic matter in sewage air is easily detected by the nose, and with some a strong smell of decomposing animal matter will even leave a taste in the mouth, which may be detected for hours or even days; this is especially the case with those who are not accustomed to such effluvia.

Mr. Laws found that the amount of carbonic acid gas in sewage air is, on the average, a little more than double that which is generally to be found in the upper air. What may be called the normal quantity of carbonic acid gas in the upper air is ·04 per cent. Mr. Laws found that in the King's Scholars Pond sewer the amount of carbonic acid gas varied from ·044 as a minimum to ·1604 as a maximum, and that the average quantity was ·0918 per cent. But this quantity of carbonic acid gas is not sufficient of itself to produce unpleasant effects when breathed. Dr. Angus Smith states that he found ·1 per cent. in the air of a well-ventilated soda-water factory in Manchester, and it was believed to produce no bad effects on the workers. But, as Messrs. Harold Wager and Auberon Herbert show in a little book recently published by Messrs. Williams and Norgate, entitled "Bad Air and Bad Health," when in a crowded room the amount of carbonic acid gas arising from respiration reaches ·08 per cent. the air becomes disagreeably close, and an unpleasant odour is experienced which gives rise to headaches. They believe and endeavour to show that this is caused by the organic impurities expired from the lungs; but the residual differences which give rise to the remarkably different physiological effects of the bracing air of mountains and the seaside, as compared with the close air of cities, remains almost as much a mystery as it was to the early chemists, who could detect no sensible difference on analysis.

M. Ch. Féré, who has written a remarkable work on the "Pathology of the Emotions," has brought together many facts tending to prove that the emotions have an intimate connection with liability to infectious diseases. He quotes some curious statistics with respect to the facility with which weak-minded persons succumb to acute diseases, and endeavours to prove that depressing emotions have an action on the development of tuberculosis, phthisis, and especially on puerperal infection—his theory being that the depressing emotions have an action on the development and healthy activity of the leucocytes or white globules, whose chief mission is to protect the organism against the invasion of microbes.

The following is the sort of evidence referred to: M. Hervieux, resident medical officer of a lying-in hospital, made notes as to the effect of the moral emotions on puerperal infection, and found a large number of cases in which young women, in a fair way towards recovery, had taken a chill and become mortally ill after a visit or untimely reproaches from their mother or relatives, or after the agitation or perplexity occasioned by their resolving to abandon their child—unfortunate girls, till then doing well, falling ill on carrying out the resolution and succumbing in a short time.

If fear plays a part in the spread of zymotic disease, it is evidently important to sweep away any superstitious dread of conditions which may not really be dangerous. With the spread of sanitary appliances there has been a wide spread of sanitary theories, some of which are evidently no better than depressing superstitions. The improved sanitary conditions have generally brought with them an increase of light, cleanliness, and ventilation, but they have been working concurrently with the depressing influence of the fear of an unseen enemy—sewer air—which was believed to bear with it deadly microbes.

The following figures, taken from the fifty-fourth annual report of the Registrar-General, published in 1892, show how little the effect of these sanitary improvements, working concurrently with such depressing superstitions, and the increasing strain of modern life with its trains and telephones and social discontent, has been upon the number of deaths from zymotic disease, though the number of deaths from all causes, per million of the population per annum, has steadily decreased from 1858 to 1890.

Annual Death Rates from Various Causes to a Million Persons living in Groups of Years from 1858—1890.

Cause of Death.	3 Yrs. 1858-60	5 Yrs. 1861-65	5 Yrs. 1866-70	5 Yrs. 1871-75	5 Yrs. 1876-80	5 Yrs. 1881-85	5 Yrs. 1886-90
From all Causes ...	22221·3	22582·0	22424·6	21932·4	20791·0	19403·4	18895·4
Small Pox	219·3	218·6	104·8	470·8	78·4	76·4	13·2
Measles	480·0	456·6	428·4	373·2	384·8	413·0	468·4
Scarlet Fever ...	891·0	982·4	959·8	758·6	679·6	435·8	240·6
Typhus	792·0	921·8	849·8	81·4	34·2	22·8	6·6
Enteric Fever				373·8	277·2	216·0	179·2
Simple and Ill-defined Fever				140·2	69·2	34·2	16·6
Whooping Cough	494·3	515·8	545·0	498·6	527·0	458·6	443·6
Diphtheria... ...	372·3	247·6	126·8	120·8	121·8	156·2	169·6
Other Miasmatic Diseases... ...	75·7	46·0	59·6	25·4	18·2	17·0	45·6

Science Notes.

There appears to be some probability of the ultimate extinction of india-rubber-producing trees. It is proposed to preserve existing forest and thickets, and to require that collectors working a grove should plant, at the same time, a certain number of trees. It is also stated, in a paper by Dr. Ernst on this subject, that the primitive and wasteful method of evaporating the juice over a wood fire is still extensively practised, instead of the improved processes now known. It would not only be a public inconvenience, but possibly even a severe hindrance to certain branches of scientific work, if an india-rubber famine were to occur.

The discovery of a fault in south-west Cornwall has been prophesied by Mr. Charles Davison on the strength of the phenomena of the Cornwall earthquakes of May, 1892. He would infer that the fault will run east and west, and slope to the south. Such a fault is not shown on the geological survey map of the district. Mr. Davison is of opinion that these shocks are the last dying movements of the series of changes in relative level which have resulted in the formation of the English Channel. A cursory glance at the survey map of the region, however, will incline the reader to the view that the general direction of the faults in Cornwall is north-west and south-east rather than parallel with the Channel axis, as this view would seem to require.

XUM

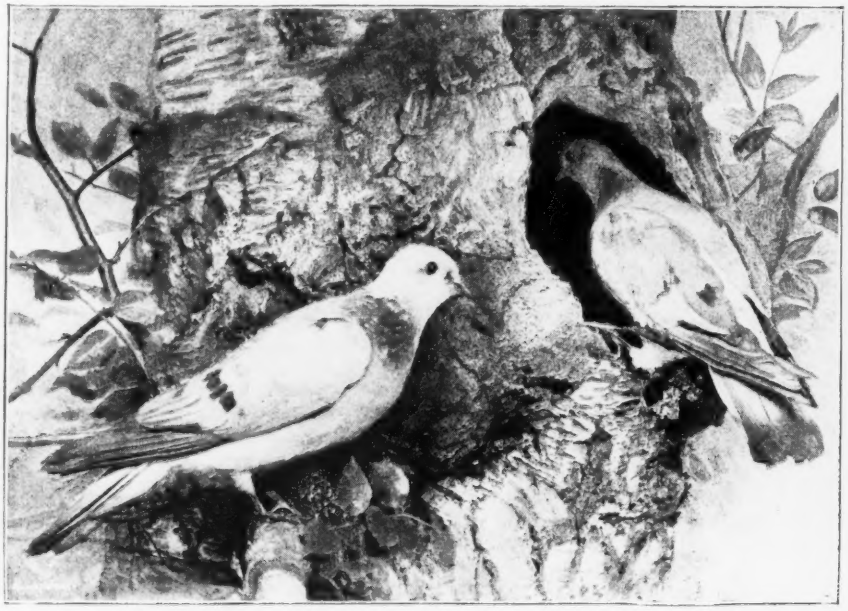
THE STOCK DOVE.

By Harry F. Witherby.

THE Stock Dove (*Columba œnas*) is so called on account of its habit of building in the stocks of trees. Once, it was erroneously supposed that our domestic pigeons sprung from this bird, and hence some thought it had thus acquired the name of Stock Dove. It frequents woods and coppices, and does not seem to mind what sort of trees they are composed of. The Stock Dove is often confused with the Rock Dove (*C. livia*), a bird very much like it in colour and general appearance, but widely differing from it in its habits.

The Rock Dove is probably the species from which all our domestic pigeons are derived. It is an inhabitant of rocky places on the sea coast, and frequently builds in companies in caves; it is especially common in Scotland, where the Stock Dove is rarely seen. Unless in very exceptional circumstances, the Rock Dove and the domestic pigeon do not roost or even settle in trees, and in this both differ from all other members of the pigeon tribe.

Again, the Rock Dove may always be distinguished from the Stock Dove and other wild pigeons by a patch of white feathers on the back, just above the tail: a distinguishing mark which is apparent in most varieties of the domestic pigeon.



Stock Doves: Male on the left, Female entering nest.

The Stock Dove is very local in its habits, being plentiful in some districts and scarce in others. In England it is not found far north, but is common in certain localities of Norfolk; and the same may be said of its occurrence in most of the midland counties. It is also common in some places in Hampshire and other southern counties. In certain parts of the country it remains all the year round, while in others it is migratory, leaving its breeding haunts about the end of October.

The nest, if a collection of sticks may be so termed, is usually placed in a hole of an old or pollard tree. The height of the hole from the ground varies considerably, a hole not more than five or six feet up being sometimes chosen, whilst at others it is often as many as sixty feet from the ground. The same place is very often resorted to year after year, and the nest is thus gradually increased in size.

I have seen one in a hollow tree, which consisted of a mass of sticks some three feet deep; and on the top of this a Stock Dove was sitting on two eggs, going in and out through a hole on the east side of the tree. On the south side of the tree, and about a foot below the Stock Dove, was another hole in the tree. Here, in a cavity formed by some of the sticks having fallen away, a Tawny Owl (*Strix aluco*) was sitting on her eggs. Taking a stand below where the Owl was sitting, and looking up through a crevice, the Stock Dove could be seen on her nest above. This strange partnership was the more remarkable as the Stock Doves feed their young in the day, while the Owls are abroad at night. Both pairs went about their duties peaceably, and did not seem inclined to molest each other.

In the open country of Norfolk the Stock Dove lays its eggs in deserted rabbit burrows, about a yard from the entrance, often not making any nest, but laying on the bare ground. It also occasionally builds under very thick furze bushes.

It rears two broods in the year, the first eggs being laid at the end of March or beginning of April. The eggs are usually two in number, but occasionally three are found. They are pure white, very much like those of the Wood-pigeon, but somewhat shorter. The birds sit very closely during incubation, both taking their turn on the nest; the young are hatched in about seventeen days. When about four or five weeks old, they are considered a great delicacy. If reared from the nest they become very tame in captivity.

The food of the Stock Dove consists of buds, young green leaves, seeds of plants and trees such as acorns and beech-mast, and grains of various sorts. They may often be seen feeding with Wood pigeons, and in the autumn and winter many join the flocks of these birds and cause great devastation in the cornfields.

The flight of the Stock Dove is exceedingly rapid, and when driven from its nest it comes out of the hole with a rush, and beating its wings together once or twice with a loud noise, it dashes swiftly away.

The note of the Stock Dove is a simple "coo-oo-oo," the last syllables being more prolonged than the first.

The length of fully-grown male birds is about one foot two inches, and their stretch of wing is about two feet two inches.

The head and crown are bluish-grey, the back of the neck being of the same colour, whilst the sides of the neck are of glossy iridescent green and claret colour. From this claret colour on the neck it derives its Latin name *œnas*, from οἶνος—wine. The breast is a purple-red, shading off downwards to bluish-grey. The back is bluish-brown above

XUM

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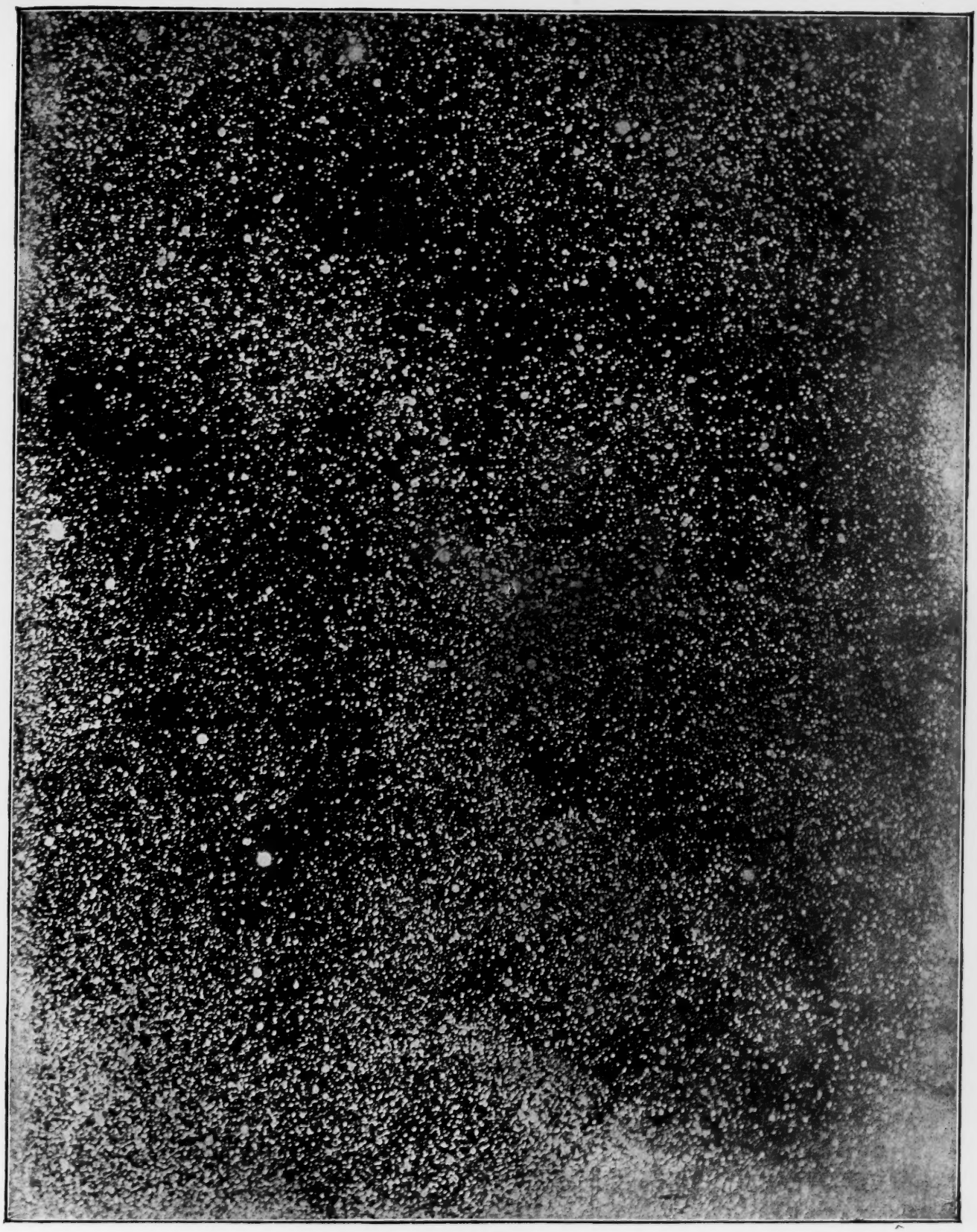
NORTH.

EAST. WEST.

THE MILKY WAY IN THE CONSTELLATION CEPHEUS.

From a photograph taken at the Lick Observatory by Mr. E E. BARNARD, with a camera of 6 inches aperture and 31 inches focus. Exposed for seven hours on October 13th, 1893, from 8H. 20M. to 15H. 20M., Standard Pacific Time. Scale of this plate:— 1 inch equal to about 1·85°. The large star in the upper right hand corner is α Cepheus.



EAST. SOUTH. WEST.

THE MILKY WAY IN THE CONSTELLATION CEPHEUS, showing the nebulous region and dark structures which are traceable on a smaller scale on the opposite page.

This plate corresponds with the central region of the opposite plate, but the photograph has been enlarged about 2½ diameters, and has been printed so as to show fainter nebulosity.

XUM

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XUM

and bluish-grey between the wings, while the tail coverts are grey. The tail and wings are bluish-grey, shading off to a leaden-grey.

The female, as is the case with most of the pigeon family, is smaller and less brilliant in colouring than the male; but otherwise she resembles her mate. Young birds, before their first moult, have not the beautiful metallic tints spoken of above on their necks.

THE STRUCTURE OF THE MILKY WAY.

By A. C. Ranyard.

THE beautiful photograph of the Milky Way in Cepheus, reproduced in our plates, will well repay very careful study. The plate on the left hand will bear examination with a magnifying lens, and if there still remain any readers of Knowledge who are sceptical as to the actual existence of dark structures in the Milky Way, they will find ample evidence in this plate to convince them of the existence of narrow streams and branching tree-like structures of semi-opaque material, which evidently acts like a fog in space, cutting out the light of the bright nebulous matter on which the dark structures are seen superposed—evidence which, if thoughtfully studied, must completely satisfy the objectors who have rather hastily advocated the theory that the dark channels and tree-like structures may be explained as accidental interspaces between bright nebulous clouds.

The plate on the right hand has been made on an enlarged scale (about two and one-eighth diameters) from the central region of the photograph represented in the opposite plate. It has also been treated so as to bring out with greater contrast the gradation of faint tints, so that some of the long lines of stars and associated dark channels are more strikingly exhibited in the enlarged picture than in the smaller but sharper reproduction of Mr. Barnard's original photograph.

I will ask the reader to devote a little time to the careful examination of both of the large plates of the region reproduced in Fig. 1. Close to the bottom edge of Fig. 1, over the words "a little," is a narrow dark channel which leads into a large dark area, within which a few isolated stars are sprinkled. From this dark area spring several branching dark structures. The most notable of them is one which reaches nearly to the top of the block in Fig. 1. From it there spring several small dark branches or expansions of the main stream on either hand.

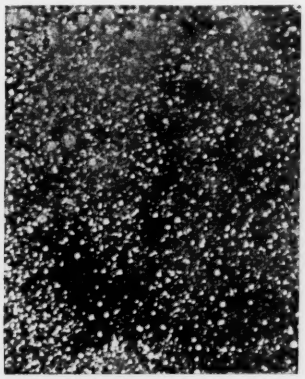

Fig. 1.—Region a little to the right of the centre on the enlarged plate, and a little below the line joining the words "East" and "West" on the opposite plate.

There are at least three such expanding heads, or opposite pairs of branches, one above the above. I would ask the reader to compare it with the great branching structure in the Orion nebula, referred to later on. This is not by any means the only dark branching structure which springs from the large dark area shown in Fig. 1. Another series of dark branching channels may be traced springing from the upper part of the dark area on the left hand. They branch in a complicated manner, and mostly end in expanded heads. There are also some narrow, dark, branching channels which run into the nebulosity on the left-hand side of the dark area.

It will be seen that all the linear dark channels and dark structures branch or fork in a direction away from the dark area, and it seems difficult to resist the conclusion that we have evidence here of streams of dark nebulous or semi-opaque matter, which have been projected from the dark region into a surrounding resisting medium. I would ask the reader to compare this region with the region of the Milky Way in Sagittarius, shown in the photographs reproduced in the January number of Knowledge for 1893. In each case we seem to have a black area, from which dark structures radiate into surrounding bright nebulosity, and it will be remembered that we found a similar radiation of dark structures from the larger dark region in Sagittarius shown in Knowledge for December, 1891, and discussed on page 232.

In the enlarged plate, several narrow dark channels, associated with lines of stars, will be recognized running in undulating lines nearly horizontally across the plate. One of the most striking of these runs through a small dark area to the south of the dark area shown in Fig. 1. This dark channel, like most of the others, is very narrow and intensely black, and runs in a wavy line nearly from one side of the page to the other. It cannot be reasonably suggested that such a dark channel is merely the interspace between two bright nebulous areas, for such a theory would involve the assumption that both of the bright nebulous areas have irregularly curving edges which accurately fit into each other, leaving everywhere the same breadth of narrow interspace between them. The chains of stars running parallel with the dark channels also bear witness to their having a physical existence, and not being due to a mere effect of perspective.

Several such dark channels are to be found in this region of the Milky Way. One runs horizontally from *a* to *b* across the middle of the region comprised in Fig. 2, but it is best shown on the larger plates and on the glass transparencies sent by Mr. Barnard. In this region there are several minute dark channels alineated with stars, which branch away from the annular dark channel. Many of them can be recognized in Fig. 2.

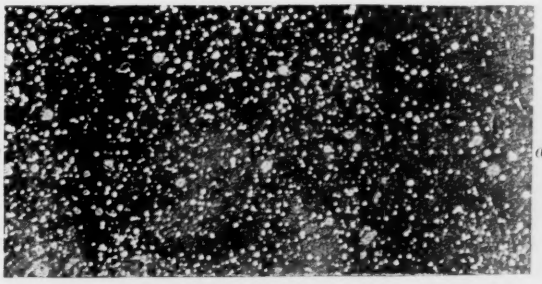

Fig. 2.—Region to the north of that shown in Fig. 1, showing bright nebulosity surrounded by a dark channel.

In trying to interpret the vast phenomena presented to us by the Milky Way, we must in the first instance note facts, and where we can recognize them we must carefully note analogies; and though the structures which have been photographed in comets, in the corona, and in the Orion nebula are probably on a diminutive scale compared with those presented to us in the Milky Way, it is interesting and may be very useful to note analogies between them.

XUM

In Swift's comet (see photographs in Knowledge for December, 1892) and in Brooks' comet (see the plate in the last number of Knowledge) we seem to have evidence of a series of tree-like and branching structures rising one above the other. In this region of the Milky Way (see Fig. 1) we have a somewhat similar series of tree-like structures one above the other, apparently arising from the same trunk or stream of outflow. Fig. 3 is a key diagram to the plate showing the structures on the eastern side of the Orion nebula. In the great branching structure which seems to spring from the eastern side of the dense quadrilateral mass of nebulosity surrounding the Trapezium, one tree-like form seems to rise above another, as if they belonged to successive outbursts that were being carried along in a stream flowing outward from the Trapezium region. If this is not the case, and there is any analogy between the prominence-like forms *b*, *c* and *d* (see index diagram, Fig. 3) and solar prominences, we must suppose that *b*, *c* and *d* have all been projected from different centres of explosion. But the cometary branching structures, which we naturally assume all come from the nucleus or head of the comet, seem to afford an explanation, or at least to throw some light upon the process by which such structures could take their form while passing through a resisting medium near or around the seat of explosion, and might afterwards be carried away in a stream as the matter of a comet's tail is carried away.

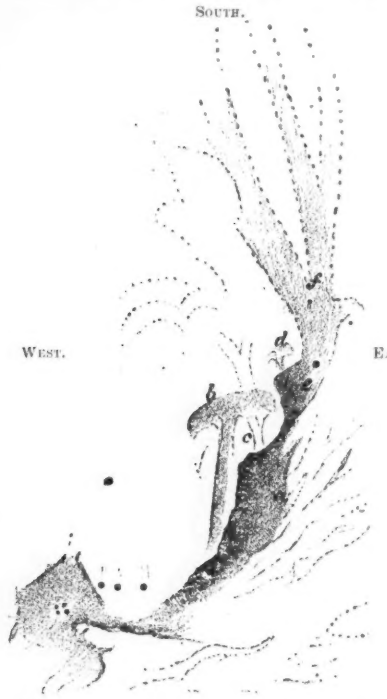

Fig. 3.—Diagram showing great curving structure on the eastern side of the Orion Nebula.

But there is a still more striking analogy between the strange form presented by Brooks' comet on the 21st October and this great structure in the Orion nebula. One edge of the structure is much sharper than the other, and it is curiously notched with sharply-defined bays or indentations on the side which is most sharply defined, as is the case with the tail of the comet. In the Orion nebula structure there are small as well as large notches. Two of these small notches are very sharply defined in the under-exposed picture (reproduced in Fig. 2 of the plate). They lie to the east of the lower part of the stem of the structure marked *b* in diagram, Fig. 3.

It is worthy of notice that the notched structure of the Orion nebula is surmounted by a branching structure very similar to the branching structure which surmounted the notched region of Brooks' comet on October 21st, and that there are other structures in the Milky Way and in nebulæ with one edge sharper than the other, and in which the sharply-defined edge exhibits notches or indentations. I would invite the reader to compare the plate of the region of the Milky Way about ξ Cygni, published in Knowledge for December, 1891, and any photograph he may possess of the nebula near ξ Orionis.

In *The American Naturalist* for January, Mr. S. W. Williston reports the discovery in the Niobrara Chalk, in Kansas, of a Plesiosaurus skeleton, with which were associated more than a hundred hard flinty pebbles, varying in weight from 1 to 170 grams, and of conspicuous colour. These he concludes had been swallowed by the Plesiosaur to aid in digestion, a habit still in vogue among crocodiles.

Dr. Hickson, in his new book, *The Fauna of the Deep Sea*, points out in a very vivid manner an extraordinary danger to which the deep-sea fish are liable. At the great depths at which they live the pressure is enormous—about two and a half tons on the square inch at a depth of two thousand five hundred fathoms. It sometimes happens that in the excitement of chasing a prospective meal the unwary fish rises too high above his usual sphere of life, when the gases in the swimming bladder expand, and he is driven by his increasing buoyancy rapidly to the surface. If he has not gone too far when consciousness of his danger grows greater than his eagerness for prey, the muscles of the body may be able to counteract this, but above this limit he will continue to float upward, the swimming bladder getting more and more inflated as the unfortunate creature rises. Death by internal rupture results during this upward fall, and thus it happens that deep-sea fish are at times found dead and floating on the surface of the ocean, having *tumbled up* from the abyss.

Notice of Book.

The Dawn of Astronomy: a Study of the Temple-Worship and Mythology of the Ancient Egyptians. By J. Norman Lockyer. London, 1894.

The idea upon which this work is based occurred to Mr. Lockyer while inspecting the ruins at Eleusis, and the remains of the Parthenon, in the spring of 1890. The directions given to the foundation-lines of these buildings struck him as peculiar, and implied, he rightly conceived, an underlying motive. Old Christian churches, he remembered to have heard, were often built so that, on their respective feast-days, the rising sun should shine directly through their eastern windows. Could it be that this arrangement was merely a survival of an antique practice? He turned to Egypt for a reply. There, numerous temples, dating from a grey fore-time, had been measured by the French in 1798, and by the Prussians in 1844. There, too, astronomical considerations were known to have been, in some cases at any rate, influential upon architecture. The Great Pyramid is a standing example. If our readers desire to satisfy themselves upon the point, they need only refer to Mr. Proctor's demonstration in "The Old and New Astronomy," that the tomb of Cheops was used, some five thousand years ago, as a meridian observatory.

To Egypt, accordingly, our present author went both in person and by manifold inquiries; with results of most curious interest. To some among them exception may be

taken; but he claims for none more than a provisional character. There can, however, be little doubt that all the sacred edifices in the Nile valley were built with some reference to the heavenly bodies. This is suggested by their very structure. From the inner sanctuary of each, the line of view was invariably kept clear to the horizon, whither the eye was often guided through rows of massive pylons, or along far-stretching avenues lined with obelisks, columns, or statues. The purpose of this open light-route was evidently that the rays of a rising or setting luminary might, at certain annually recurring moments, flash transitorily upon the image of the enthroned divinity. "Manifestations" of this kind are indeed positively stated in some of the mural inscriptions to have given the signal for the commencement of solemn celebrations; hence the temples were expressly planned to secure their unfailing display. For the most part, it was sun-illumination which was thus led captive to the shrine of the god or goddess; but a considerable number of temples face too far south or north of the equator to have ever been available for solar observations. These, we are now informed, were oriented, each to a particular star. Thus, there can be no question but that the goddess Isis was represented in the heavens by the blazing Sirius; and it may also be admitted that the temple of Isis at Dendera was erected as a kind of spy-tube upon the yearly reappearances at dawn of her stellar *alter ego*. This took place on the 20th of June, the Egyptian New Year's Day, and was hailed with clamorous exultation. From a comparison of the actual aspect of the temple with the lie it should now take in order to comply with the ancient conditions of its existence, Mr. Lockyer places its foundation at about 700 B.C. The localization of a star naturally implies a date, since precessional movements occasion a continual shifting of rising-points, as viewed from any determinate spot on the earth's surface. A temple, of which the axis was designed to be threaded by the emerging beams of a certain star, must then have been built at a strictly calculable epoch. In two, or at the utmost three hundred years, it would become superannuated. The star of its cult would no longer shine into it. Originally aligned with a moving object, it now remains as a perennial record of the interval which has elapsed since that primary, though comparatively transient, agreement was complete. Hence the chronological value of this method, provided only that satisfactory assurance can be obtained as to the individual stars to which the temples were oriented. Mr. Lockyer's identifications are not meant to be final. The admission of Canopus, it may be remarked, as an object of worship in Upper Egypt, would carry the time back to 6400 B.C. A great deal of research, however, including surveying operations and the labours of decipherers, is requisite before the brilliant suggestions contained in the volume before us can be either received or rejected without hesitation.

Letters.

[The Editor does not hold himself responsible for the opinions or statements of correspondents.]

IRREGULARITIES IN THE TAILS OF COMETS.

To the Editor of KNOWLEDGE.

DEAR SIR,—I have been very much interested by the articles on Brooks' Comet in the last number. On the one hand, it seems to me that Prof. Barnard does not prove the assumption which gives the title to his article—"On the Probable Encounter of Brooks' Comet with a Disturbing Medium"; and, on the other hand, I do not understand how the explosions you speak of, or the great and sudden changes in brightness, could be caused without some encounter or external influence more irregular in its action than the slow increase or decrease of the sun's heat, due to the comet's changing position. Prof. Barnard seems to assume that the whole comet was stirred up by the collision of its tail with a resisting medium. He says:—"In the second photograph (see the picture for October 21st) the entire comet was brighter, *as if the disturbance had added to its light*" [the italics are my own]; and he goes on to say, "as also seems to have been the case with the third photograph on October 22nd, for its exposure was much shorter, as flying clouds were obscuring the sky a considerable portion of the time." No doubt the rapidly-varying brightness is proved beyond dispute by the photographs, but I do not see how a blow upon a comet's tail could affect the brightness of its head or nucleus. If the matter of the tail is, as we have hitherto supposed, always streaming away from the nucleus, such a theory, at all events, needs further proof than Prof. Barnard gives.

It seems to me more probable that the irregularities in the tail are as you, Mr. Editor, suggest, due to irregularities in the quantity of matter streaming away from the nucleus, as well as due to changes in the direction in which the streams of matter are driven forth from the head of the comet. But I cannot conceive how the sun's slowly increasing heat acting upon the nucleus could cause such sudden outbursts in different directions.

The phenomena presented are intensely interesting because they are so mysterious. My father felt great difficulty in accepting the ordinarily received theory that comets have been captured from outer space and deflected into closed orbits by the larger planets, because, with bodies of sensible diameter like comets, the nearer and further parts would be differently acted upon by the planets they approached, and the various parts of a large group of stones would consequently be deflected into very different orbits.

The elongated nuclei of some comets, and the small attendant comets which have been seen alongside some large comets, seem to show that the material of the nucleus has been torn into pieces by perturbations, and has in some instances been stretched out into a stream of nuclei or isolated clusters of stones arranged in a line. It seems to me to be worth considering whether the notches in the tail of Brooks' comet may not have been due to some repelling action around an invisible attendant comet, such as was observed, or, at all events, was photographed by Prof. Barnard, in the midst of the tail of Swift's comet.

It will also be seen that the ejected matter from the nucleus was pretty evenly distributed on either side, as it streamed away from the head of the comet, while if something had run against the tail of the comet, its fragments would have been drifted to one side of the general axis of the tail. In the second photograph, taken on October 22nd, the even distribution of matter driven back from the nucleus is even more noticeable.

Yours faithfully,

Brighton, 7th February, 1894. HARRY PROCTOR.

[Many of the older readers of KNOWLEDGE will, I feel sure, join with me in welcoming Mr. Harry Proctor as a contributor to our pages. His theory, as to the possible action of attendant comets, seems to me to be well worthy of consideration. We know that some three or four comets, whose paths approach the earth's orbit, are accompanied by widely distributed flights of meteors distributed along and around their orbits. If the matter driven from the main nucleus of a comet varies in quantity from day to day and

hour to hour, it is easy to conceive that smaller swarms, which accompany the main cluster, may from similar causes vary in brightness, sometimes becoming bright enough to be recognizable, and then rapidly dying down in brightness so as to be lost to sight again.—A. C. Ranyard.]

To the Editor of Knowledge.

Leigh Sinton, Malvern,
February 9th.

Dear Sir,—I was greatly pleased with the photo-reproduction of the summit of Mount Hamilton and the Lick Observatory in this month's Knowledge; but I looked in vain for any letterpress description. I have never seen anything beyond the usual type of newspaper paragraphs about it, and I am sure that other readers besides myself would be interested in some reliable statements. *E.g.*, Is the full aperture of the giant lens normally used on fine nights? What power can be used on double stars and on planets respectively? Does Jupiter appear as clear and free from halo and colour as in a 6-inch instrument? Also, are photographs of the planets successfully made? You have familiarized your readers with exquisite photos of the moon and of star-groups, but I have never seen any attempt at a photographic view of, say, Jupiter or Saturn.

Yours truly,
C. Robinson, B.A.

[Photographs of Jupiter and Saturn will be found in Knowledge for November, 1890. The photographs there reproduced are from negatives taken by Prof. W. H. Pickering. Good photographs of the planets have been obtained at the Lick Observatory, and also by the Brothers Henry and M. Loewy at the Paris Observatory; but comparatively little progress has been made in this direction since 1890. Both Jupiter and Saturn show a great deal of colour in the most perfect achromatic telescopes, as well as in reflecting telescopes. The globe of Saturn exhibits delicate tints of blue and brown, and Jupiter is exquisitely coloured with deep tints of red, yellow, blue, and rich chocolate brown.

As far as I am aware the full aperture of the 36-inch refractor is always used, but none of these great telescopes bear a power of 100 per inch of diameter, which is spoken of by the Rev. T. W. Webb in his "Celestial Objects" as the power which the best telescopes of either kind (*i.e.*, reflecting and refracting) should bear under favourable circumstances on stars. It seems to me, though I feel great diffidence in differing on such a subject from Mr. Webb, that he would have been nearer the mark if he had spoken of a power of 40 or 50 per inch as the limiting power which can be advantageously used on large telescopes under favourable circumstances. I should like to hear what Mr. Burnham and Mr. Barnard have to say on this subject.—A. C. Ranyard.]

PERIODICAL COMETS.

To the Editor of Knowledge.

Sir,—Let me remind Mr. Denning that in Dr. Matthiesen's paper, to which he refers, it is expressly stated that if the comet, as seemed probable and we now know was the case, escaped observation in 1890, it would be very difficult to predict the approximate time of its appearance at the next following return. It underwent some rather strong perturbations by Jupiter in 1887; and though Dr. Matthiesen did take account of these so far as was practicable, it must be remembered that the whole time of the comet's visibility in 1881 was considerably less than three months, so that the knowledge of its motion in its present orbit could not be very precise, nor the means of calculating the perturbations very accurate.

In my list of expected returns of comets, both in my article in Knowledge and in my little *brochure* on "Remarkable Comets," to which Mr. Denning does me the honour to refer, I limited my notices to those of which the return might be expected with some confidence during the years assigned. For this reason I omitted both Denning's comet of 1881 and the comet which was known as Tempel's second periodical comet. The latter was seen at two returns only, and escaped observation during those due late in 1883 and early in 1889. It is true that the positions were unfavourable on both these occasions, but comets seldom escape observation now entirely from that cause, being so diligently looked for in both hemispheres with much more powerful telescopes than formerly. Another return will be due shortly, but under the above circumstances can hardly be looked forward to with much confidence.

In my article I inadvertently spoke of 1899 as the last year of the present century, which, of course, should be 1900. Mr. Denning apparently follows suit, and means 1897, 1898, and 1899 by "the last three years of the present century." Let us hope that his comet will return some time in the last of these, after which its period will be better known.

Yours faithfully,
Blackheath, February 9th, 1894. W. T. Lynn.

LUNAR CRATER PLAINS.

To the Editor of Knowledge.

Sir,—I have been away on a five months' cruise around the colonies of Australia, and have only just seen your interesting article—beautifully illustrated—on "The Great Lunar Crater Tycho," in Knowledge for August.

Some of the references therein to the "Theory of Lunar Surfacing by Glaciation" (published by Messrs. Thacker and Co., 87, Newgate Street) have taken me rather aback, and, as I am sure you would desire to see any serious misinterpretations rectified, I beg to send a few explanations.

The view of the subject which I take is so revolutionary, and it is naturally so speculative and many-sided, that I must at first expect a large amount of misapprehension, and trust to time, and opportunities such as this, to remove them as they arise.

In the first place I see you say I assume "that the lunar surface consists entirely of ice." This is hardly correct. I assume that in the main the surface, whether hill or plain, is composed of *snow*; occasionally and rarely of ice, as in the three dark spots on "Alphonsus," which, even then, would be so covered with floe *débris* and meteoric dust stain, that specular reflection would be impossible.

Beneath this snowed surface—especially on the maria and sunk plains—the ice, I take it, lies hidden, more or less roughened by *débris*, yet often level in the main over large areas. Hence I do not look on the "lunar plains as surfaces of virgin ice," as many suppose, capable of specular reflection.

At page 11 of the "Theory" above referred to I say "the outer surface is a snow surface stained by an accumulation of meteoric dust."

Again, you say that I think "the craters and pit-like depressions are due to the action of hot springs, which have not flowed continuously, but that water has from time to time issued from vents in the soil, and has melted the ice above the vent; the water is then supposed to have flowed back to the warm interior of the moon, taking with

it a part of the surface ice that has been melted, and by a series of such ebbs and flows Mr. Peal conceives the terraced walls of the lunar craters to have been built up."

I do not recollect ever having referred to springs of hot water or ebbing and flowing. The "vents" and "heat orifice" I take to be similar to those seen in terrestrial volcanoes, where, as Prof. Judd points out, some ninety per cent. of the total output is steam, or heated aqueous vapour.

On page 22 of the "Theory" I call them "cold volcanoes."

On our earth we have numerous cases of submarine vents, which at times raise the temperature of the water, and even at last rise to the surface and form the "oceanic islands." All I assume is that these existed on the moon, and during its long era of refrigeration they retarded, for very long periods, the glaciation of the sea on large and small sub-circular areas, a cluster of small heat orifices or vents, as in Plato, at times producing a lagoon in the ice sheet, as effectually as one large one.

But in all cases a time must necessarily come when, through the persistent fall in secular temperature, these lagoons, in various stages of formation, solidified, and any aqueous vapour subsequently given off at the old or any new orifice, would be piled as snow over and around the vent, and would form the well-known "cone," simulating our volcanic cones, in all but their universal whiteness.

In the deeply terraced craters—which, as a class, are not overlapped by other rings—the material of the successive terraces I assume to be taken from the lagoon surface by evaporation, and deposited at once around the margin as snow, thus at one operation forming the new terrace, and still further lowering the level of the enclosed floor.

Ice cliffs of seventeen thousand and twenty thousand feet high are no part of my "theory." On page 8 of it I say, "again it has been objected that snow mountains of twenty thousand feet elevation are quite inconceivable, but we may recollect that the gravitation on the moon would be but one-sixth of ours, and that thus the lunar snow in packing down, or piling up, would probably not have one-fourth the same mass in an equal volume as ours. Terrestrial ice on the moon would weigh lighter than cork to us, and lunar snow peaks and ridges would rise as an almost inconceivably light material, into an intensely cold airless void. Though of such a light and flocculent nature, they would appear to us, and practically be, as permanent as solid rock masses. With us the lower layers of deeply piled snow become pressed to ice, and there seems to be no reason why the bases of lunar ranges should not be of similar nature."

I may add that it is now found that at low temperatures ice becomes a non-viscous solid, like glass; and that as temperature falls, both snow and ice become more and more diathermanous.

The occurrence of small craterlets on the rims and slopes of large craters and sides of mountains I, of course, do not attribute to an output of "warm water," but to the exhalation of *steam* through orifices due to faulting—similar to the formation of the crater chains over faults or clefts.

The extraordinary outcrop of minute crater cones *all over* the lunar surface, which is probably still going on, when taken in conjunction with the slow subsidence of the lunar maria, as evidenced by the clefts, seems to me a beautiful demonstration that there is still a large store of internal heat in our satellite, beneath the now glaciated crust.

I "account for the fact that the lunar plains and floors of the deeper lunar craters are generally of a much darker tint than the higher ground upon the moon," not by assuming that the former are virgin ice, and the latter snow, but solely as the effect of gravitation, which occasionally removes from cliffs, rugged and elevated regions, the meteoric dust stain, which needs must lie (and accumulate) for ages on levels and gentle slopes, like the outer incline of the rings—see Aristarchus, &c.—at sunrise.

Sibsagar, Assam. S. E. PEAL.

[If the lunar plains had acquired their dark tints by the fall of meteoric matter which was originally deposited on high ground, we should expect to find the darker colouring near the base of the lunar mountain ranges, and that all high ground would be fringed by an edging of darker shade. But the dark tints are nearly uniformly distributed over the lunar plains, and we seem to have evidence in lunar photographs that matter of various degrees of darkness, as well as white material, has flowed in streams from some of the lunar craters.—A. C. RANYARD.]

ANIMAL HEAT.

By VAUGHAN CORNISH, M.Sc., F.C.S.

IN a former article it was shown how plants and animals assimilate food from their environment, seizing upon the same elements and building up compound substances, which, though not identical, are of the same general character and class in both the vegetable and the animal world.

In our last two articles we described the changes of composition which take place in the life of plants and animals as essentially chemical changes, following the same laws and brought about by similar causes as the reactions studied by a chemist in his laboratory. In the growth of the animal or plant many causes co-operate besides chemical causes. For example, the form and structure of its parts are determined by laws which are outside the ken of the chemist. But chemical forces, besides building up the substances of which animal and vegetable bodies are made, maintain the bodily heat which is inseparable from animal life, and which, along with the power of locomotion, forms to the ordinary observer perhaps the most obvious and essential distinction between animals and plants. Lavoisier first proved to the world the nature of the chemical changes which occur in burning, and showed that in respiration the same chemical process (oxidation) is going on. Every chemical change is accompanied by a heat change. Lavoisier not only recognized this fact, but he appreciated its importance more than most of his immediate successors. Accordingly he set himself to investigate *quantitatively* the heat changes which occur in the phenomena of burning and of respiration, both being from his point of view phenomena of oxidation.

How well Lavoisier understood that without measurement there is no science is shown by the fact that he used the *calorimeter*, or instrument for measuring quantities of heat, with the same diligence as he showed in the use of the balance. Calorimetry, that branch of science which deals with the measurement of quantities of heat, owes its origin to the joint work of Lavoisier and Laplace, who were the inventors of the ice-calorimeter. The principle of their method was to measure the quantity of heat by the weight of ice melted. Thus, in order to determine the quantity of heat given out by one pound weight of iron in cooling from the temperature of boiling water to that of melting ice, the iron was placed in the central chamber of a box furnished with a lid and having two annular chambers

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outside the central chamber. The outer annular chamber or compartment was filled with ice to protect the next compartment, also filled with ice, from the warming effects of the external air. All the heat received by the inner ice compartment comes, therefore, from the body placed in the central chamber. The weight of ice melted measures the quantity of heat received, the water formed by the melting of the ice being run off from the bottom of the apparatus, which is funnel-shaped and provided with a stop-cock for the purpose. The above arrangements served for the comparison of the specific capacities for heat of different materials, as shown by the heat given out by them in cooling through a certain range of temperature.

In the experiments on the heat given out in burning and in respiration, the arrangements were slightly different. We give Lavoisier's description, retaining the old term *caloric*, which may be taken to mean "heat considered as a measurable quantity." Lavoisier writes: "To determine the quantity of caloric disengaged during combustion and during animal respiration, the combustible bodies are burnt, or the animals are made to breathe, in the interior cavity, and the water produced is carefully collected. Guinea-pigs, which resist the effects of cold extremely well, are well adapted for this experiment. As the continual renewal of air is absolutely necessary in such experiments, we blow fresh air into the interior cavity of the calorimeter by means of a pipe destined for that purpose, and allow it to escape through another pipe of the same kind; and that the heat of the air may not produce errors in the result of the experiments, the tube which conveys it into the machine is made to pass through pounded ice, that it may be reduced to 32° before it arrives at the calorimeter. The air which escapes must likewise be made to pass through a tube surrounded by ice included in the interior cavity of the machine, and the water which is there produced must make a part of what is collected, because the caloric disengaged from the air is part of the product of the experiment."

By means of this apparatus, or "machine" as he calls it, Lavoisier compared the quantities of heat evolved during the burning of a given weight of carbon and of hydrogen, and of a given weight of animal and vegetable substances formed of carbon and hydrogen, such as wax in a wax taper, and olive oil burnt in a little lamp. He also, as we have seen, determined "the quantity of caloric disengaged during respiration," a research connected with that on the loss of weight during respiration, in which his colleague Seguin was the *corpus vile* in place of the guinea-pig, which was found so "well adapted" for calorimetry. Seguin used to be sewn up in a varnished air-tight silk bag, the edges of which were accurately cemented round his mouth, leaving only a slit for breathing. He was weighed in a delicate balance from time to time.

Since the days of Lavoisier thermo-chemistry, or the study of the heat-changes which accompany changes of chemical composition, has made considerable progress in spite of the many practical difficulties which surround the subject. One of the most important of the laws which have been experimentally established is that "the initial and final stages of a chemical reaction alone determine the amount of the heat change."

For instance, the conversion of a given weight of carbon to carbonic acid is accompanied by the evolution of a quantity of heat which is the same whether the carbon be burnt rapidly in oxygen, or whether in a slow and roundabout series of chemical changes the carbon is successively a constituent of a number of vegetable and animal substances before finally attaining the form of carbonic acid in the expired breath of animals. This law, which has been experimentally proved to hold in a variety of cases, enables us to calculate the heat-giving power of foods without having to ascertain the various changes and modifications which the food undergoes in the animal body. We know the final products, and that is sufficient. Thus, sugar taken into the body is sooner or later completely converted into carbonic acid and water; in other words, it is completely burnt. The heat given to the body by one ounce of sugar is therefore, by the second law of thermo-chemistry as it is called, the same as the heat evolved by burning an ounce of sugar. This quantity can be experimentally determined by the use of Lavoisier's calorimeter, or one of the modern improvements upon his original apparatus. We are thus enabled readily to compare the heat-giving power of different foods and food stuffs, and it is by the use of such thermo-chemical methods that the figures quoted in previous articles have been ascertained. For instance, the starch equivalent of fats, two-and-one-third, is the proportion which the heat-giving power of fats bears to that of an equal weight of starch.

Every chemical change is accompanied by a heat change, but it must not therefore be supposed that every chemical reaction is accompanied by an evolution of heat. There may equally well be a disappearance of heat. It is the former class of reaction, those in which heat is evolved, which are often accompanied by striking phenomena such as evolution of light, &c. Hence the popular idea that a chemical change is necessarily accompanied by an evolution of light and heat. By the second law of thermo-chemistry the initial and final stages only determine the heat reaction. Take the case of the carbonic acid of the atmosphere, and the various changes the carbon undergoes after its assimilation by the green portion of a plant and during its subsequent changes in the body of some animal which has fed upon the plant. The final stage is that the carbon is restored to the air as carbonic acid. The initial and final stages are identical and the total heat reaction is *nil*. While the carbon has been in the animal body it has been gradually oxidized up to carbonic acid, and during the whole of this time heat is being evolved; hence the warmth of the animal. The heat thus given out by the carbon taken into the body as vegetable food is (by the second law of thermo-chemistry) exactly equal to the heat *absorbed* during the process of converting the carbon of carbonic acid into the state of chemical combination in which it is found in the plant. How is it, then, that the frigorific effects of plant growth are so much less patent and obvious than the heating effects of animal life? It is mainly due to the circumstance that, in order to bring about chemical changes in which there is an absorption of heat, some external agent must act, and must keep on acting, in order that the chemical reaction may proceed, and in the case of the decomposition of carbonic acid in the presence of the green colouring matter of plants this external agent is the sun's rays. Hence, the cooling effect which results from the feeding of plants upon their atmospheric food is to a great extent masked by the fact that the cooling action only takes place in presence of a potent heating agent—the sun's rays. Still, let anyone compare the climate of a forest and of a sandy desert in the same latitude, and reflect that the difference is partly due to the fact that in the one case all the heat rays are reflected back, but in the other case a part of these rays are employed, without apparent heating effect, in splitting up carbonic acid. This gives some idea of the cooling action of plant life, which contrasts so sharply with the warmth of living animals.

Let us consider for a moment what chemical changes, and heat changes, take place after the death of a plant. Decay and decomposition, which are mostly processes of oxidation, are accompanied by heating effects. Many such cases can be called to mind, such as the heating of hay in the stack. On the other hand, the surest evidence of death in animals is the loss of bodily warmth. Thus, the opposite functions of plants and animals, with regard to heat, are more sharply contrasted in the phenomena of death than of life. The contrast must not be pushed too far, since when decay sets in there is a heating effect with animals also, though not perhaps so marked as in the case of plants.

Warmth and power of locomotion we have chosen as two marked and obvious characteristics of living animals distinguishing them from plants. The power of locomotion which animals possess depends upon their warmth. The ordinary movements of an animal are made against some kind of resistance, and when motion is so accomplished physical work is performed. Physical work is measured numerically by multiplying the amount of the force by the distance moved against its resistance. All bodily work may be expressed in this way. The systematic and continuous use of the rational and thinking faculties is often called work, but for present purposes we exclude brain labour from the scope of the term "work," which we shall employ in the physical sense only. Plants cannot do work, animals can do work. Combinations of mechanism (pulley, screw, lever, &c.) cannot do work, they only vary the proportion of the two factors of work, distance and force; but engines, like animals, actually do work, for an engine is provided with a source of energy as well as with a train of mechanism. A steam engine, as far as chemical science and heat science are concerned, is closely analogous to an animal. From this point of view, it is an animal very much simplified. Energy is obtained in the steam engine and in animals by burning carbonaceous material. Both the engine and the animal can do work as long as the same chemical action furnishes them with the same kind of energy. Without fuel or food both grow cold, and no work can be done.

By the study of the steam engine, Hirn proved that every foot-pound of work done entails the disappearance of a definite quantity of heat between the boiler and the condenser of the engine. The relation is about one thousand three hundred and seventy foot-pounds of work for each unit of heat, as that quantity which will raise one pound of water one degree in temperature. Roughly, Hirn's method was as follows:—He determined the total amount of heat put into the boiler from the amount of the water supplied per diem and from the temperature of the steam. The amount of heat returned to the condenser was calculated from similar data. The amount of mechanical work done was measured by a Watt's *indicator*. In this instrument the amount of work done is indicated by the movement of a pencil point upon a sheet of paper. The position of the pencil point, which indicates the work done, is determined jointly by the pressure or *force* of the steam, and the *distance* through which the working piston has moved. The work registered by the indicator is partly the work done in overcoming the resistance of the parts of the engine, which we will call internal work, and partly external work, such as raising a weight or driving a shaft. Hirn found that, if he increased the external work of his engine, there was a greater loss of heat between the boiler and condenser of the engine, one unit quantity of heat disappearing for each one thousand three hundred and seventy foot-pounds of additional external work. A great variety of methods has given practically the same value for the mechanical equivalent of heat, and we may confidently apply the value obtained to the solution of problems upon the relation of food and work in animals. In the animal body there is "internal work" to be done, just as there is in the steam engine. In neither case can the whole of the heat furnished by the fuel or food be converted into external mechanical effect. This would require, in the case of the steam engine, that no heat at all should reach the condenser, and that the condenser should be at the absolute zero of temperature, a condition which it is impossible practically to attain. In the case of an animal, if all the heating power of its food were used for external work the temperature of the animal's body would sink to that of its inanimate surroundings, a condition obviously incompatible with life. As a matter of fact, about one-fifth of the energy which the food develops can be obtained in the form of external mechanical effect. The rest is required for the internal work of the body. This is a much larger proportion of external effect than in the case of a steam engine, or other heat engine, where the *efficiency*, or proportion of the mechanical equivalent of the heat supplied to the external work done, is more like one-twentieth per cent.

The heat developed in the body by one pound of the carbo-hydrates (starch, &c.) has a mechanical equivalent of about two thousand eight hundred and sixty foot-tons. *One* pound of oil or fat is in the same sense equivalent to six thousand four hundred and fifty foot-tons. About twenty per cent. of this is available for external work, so that we may say that if a man is to do three hundred and twelve foot tons of work he may supply himself with the requisite store of energy by taking four ounces of fatty food in addition to the *maintenance* diet necessary to meet the daily waste of the body. Three hundred and twelve foot-tons is about the average amount of work done in a day by an English labourer, whose diet would probably comprise about four and a half ounces of fat. People often puzzle themselves why it is that working makes a man hot rather than cold, seeing that heat is used up to produce mechanical effect. The analogy of the steam engine will enable us more readily to explain this apparent anomaly. When a locomotive is going sixty miles an hour, more work is being done than when it is going thirty miles an hour. More heat is converted into work when the engine is going fast than when it goes comparatively slowly; but no one would expect the heat in the engine as a whole to be less when the pace is great. The draught will be greater and the consumption of coal greater, and so much greater that, although there will be more heat converted into mechanical effect by the working of the piston, yet the engine as a whole will be hotter. It is so also in the case of the animal body. When bodily work is being done, the contracted (*i.e.*, the working) muscle seizes upon a greater quantity of the oxygen of the arterial blood than in the case of the uncontracted muscle in its state of rest. The blood of the veins may contain as much as seven and a half per cent. of oxygen when the muscles are at rest, but a working muscle may leave as little as one and a half per cent. of oxygen in the venous blood. This means that there must be a corresponding increase in the amount of carbonic acid given off by the lungs, which in fact may be as much as five times greater during work than during repose. Respiration is deeper and more rapid, more oxygen is inhaled, the combustion of the food goes on more quickly, and an increased supply of carbonaceous food is required to supply the fuel for combustion. Thus it is that the temperature of the body is maintained during work, although the work is done at the expense of food which otherwise would produce animal heat.

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THE ROOT-TUBERCLES OF PEAS, BEANS, AND VETCHES.—I.

By J. Pentland Smith, M.A., B.Sc.

A GREAT amount of interest has been excited of late by the discovery of the function and use of the nodules which are found on the roots of plants belonging to the natural order *Leguminosæ*—plants whose fruit is a pod or legume.

The subject is interesting alike to the botanist, chemist, and agriculturist; to the botanist because of the biological problems connected with it, to the chemist because of the light it sheds on the complex chemical processes occurring in the soil, and to the agriculturist from the practical conclusions to be drawn from the data afforded by purely scientific investigators. It is a fascinating subject from whatever standpoint we choose to regard it.

Agriculturists have noticed that the cultivation of one species of plant on the same soil, year after year, is detrimental to the well-being of plants; and they have found that if crops are grown in certain successions good yields are the result.

De Candolle explained this by saying that the roots of plants excrete into the soil a specific substance, injurious to crops of the same kind. It became evident, however, that by a system of rotation, not only were better crops obtained, but a smaller quantity of manure was required for their production. Liebig's explanation of the benefits accruing from a rotation of crops seems more acceptable than that of De Candolle—in fact it is now known, as the result of numerous analyses, to be the correct explanation: one species of plant abstracts from the soil larger amounts of certain salts than another.

A short *résumé* of the manner in which a plant furnished with green leaves obtains its supply of food will form a fitting introduction to this subject. The essential materials of plant food are carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, sodium, &c. This has been determined by an analysis of plant tissues and of the *living* part of the plant, the protoplasm. They must either be obtained by means of the roots from the soil in which the plant is growing, or taken from the air by the leaves. Experiments have shown that both sources are drawn on. The greater part of the carbon and oxygen are obtained from the air by the leaves, and the soil is the storehouse from which other elements are drawn. This is rather startling when we recall the fact that, estimated roughly, about four-fifths by volume of the atmosphere is composed of nitrogen, about one-fifth of oxygen, and the rest chiefly of carbon dioxide (commonly called carbonic acid gas). It has long been known that the green colouring matter, chlorophyll, in the presence of bright sunlight, possesses the power of breaking up carbon dioxide into its constituent elements, carbon and oxygen; the carbon and part of the oxygen being retained by the plant, while the remainder of the oxygen is given off into the atmosphere. In performing this function of carbon assimilation the plant is purifying the air. Though the counter process of respiration which is going on continuously day and night has the opposite effect, the oxygen evolved during the day is in excess of the carbon dioxide produced during that time by the respiratory process.

An interesting experiment, devised by Engelmann, illustrates very forcibly the part played by chlorophyll-bearing plants in the economy of the world. He projected a fine spectrum of the sun's rays on a slide containing a filamentous alga (that is, a thread-like sea-weed), and a quantity of the bacterium, *Bacterium photometricum*, which has such a passion for oxygen that it collects in its hosts at the edge of the cover glass, where there is a greater supply of that element. The result was the assemblage of masses of the bacterium in the red-yellow and blue-violet parts of the spectrum, showing that carbon assimilation was proceeding most actively at these points. Green plants are thus, by virtue of their possession of chlorophyll, the converters of the unorganized carbon dioxide of the atmosphere into a form available for plant

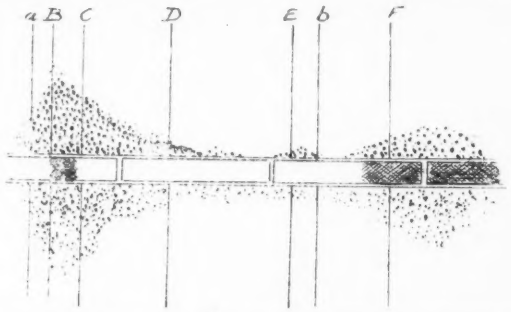


Fig. 1.—A filamentous Alga, on which the solar spectrum has been projected. (After Engelmann and Vines.) In the water are quantities of the bacterium, *Bacterium photometricum*, which have aggregated themselves in the red-yellow and blue-violet parts of the spectrum. This bacterium is an oxygen lover, and its accumulation at these parts of the spectrum shows that carbon assimilation is proceeding most actively in the regions where chlorophyll exhibits the most marked absorption bands.

food. And in the performance of this function they convert the kinetic energy of the sun's rays into a potential form, as Engelmann's experiment clearly shows. This afterwards, in becoming kinetic, supplies the motive power whereby the chlorophyllous plant is enabled to carry on its life processes, just as the potential energy of a wound-up watch spring, in changing into moving energy, carries the works of the watch; or the water, which dammed up on the hillside is endowed with potential energy in virtue of its position, assumes the kinetic form when the sluice is withdrawn, and drives the mill-wheel. This point is an extremely important one and must not be lost sight of in the discussion which follows, for according to this view of the case all non-chlorophyllous vegetable organisms and all animals must directly or indirectly prey upon chlorophyll-bearing plants, as they alone can assimilate the carbon which enters so largely into the composition of all living bodies. Hence all fungi and other plants characterized by the non-possession of chlorophyll must either be saprophytic (*i.e.*, live on dead organic matter) or parasitic (*i.e.*, prey upon the living bodies of other plants or animals). It is for this reason the suggestion has been made that green-coloured plants were the living forms first evolved from non-living matter, although this view is negatived by Ray Lankester in his article on "Protoplasm" in the *Encyclopædia Britannica*.

The water absorbed by the roots from the soil contains small quantities of salts of potassium, calcium, &c., in solution, and this is the source, as previously mentioned, of the other constituents of protoplasm. These unite with the assimilated carbon, and the resultant protoplasm is the last link in the chain of complex organic compounds formed by their union. The energy of the solar rays is consumed in the production of plant protoplasm, and the decomposition of this substance supplies the kinetic energy that is the motive power of the life processes of all other plants and of animals.

During the last fifty years Sir John Lawes and

Dr. (now Sir) J. Gilbert have carried on an elaborate series of investigations in scientific agriculture at Rothampstead, which has made that little place famous and has earned for the authors a world-wide renown. In the course of their numerous experiments they found that in the case of leguminous crops, such as peas, beans, and vetches, it was impossible to account

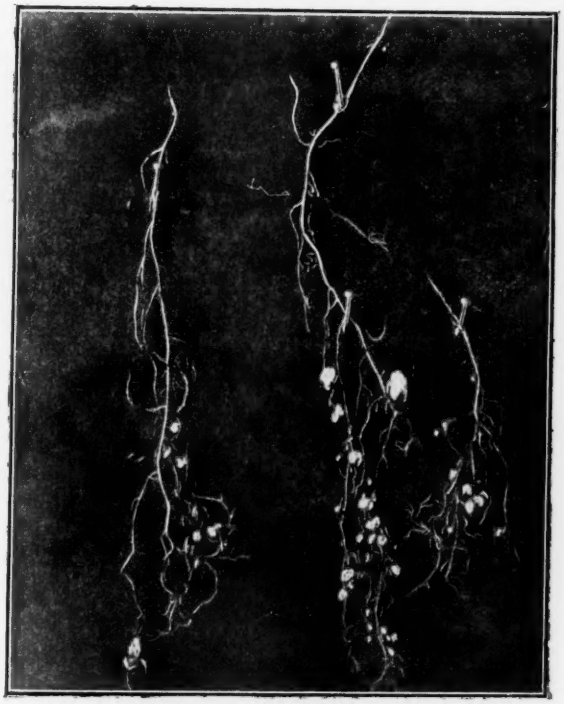


Fig. 2.—Block made from a photograph of Roots of poorly grown Pea-plants, with badly-developed nodules.

in the usual way for the whole of the nitrogen contained in them. It was in excess of what could have been derived from the rain or the combined nitrogen of the soil supplied in the manure. An examination of the roots of these plants, moreover, invariably disclosed the presence of nodules of various sizes and in varying quantities, and a chemical analysis of these tubercles showed them to be rich in nitrogen, and at certain periods teeming with minute organisms, whose life-history we shall presently discuss. Fig. 2 is a reproduction of an actual photograph of the roots of some pea-plants on which, unfortunately, the nodules are very small. The nitrogen of the air can be the only source of this extra supply of nitrogen, yet for years past it had been strenuously denied that green plants have the power of making use of this vast inexhaustible reservoir. These results, however, of two of the experimenters, startling in the extreme, again brought up the question of nitrogen fixation, and it was attacked by such men as Berthelot, Hellriegel, Wilfarth and Warrington. A paper from the pen of Lawes and Gilbert appears in the *Transactions of the Royal Society* for 1890. It commences with a summary of the results obtained up to that time. "In previous papers, of all the various results discussed, those of Hellriegel and Wilfarth were considered to be by far the most definite and significant; pointing to the conclusion that, although the higher chlorophyllous plants may not directly use the free nitrogen of the air, some of them, at any rate, may acquire nitrogen brought into combination under the influence of lower organisms, the development of which is, apparently, in some cases always coincident with the growth of the higher plant whose nutrition they are to serve." The authors then instituted experiments with a view to confirm these conclusions. They state that these have amply confirmed the results of Hellriegel, and that the fixation of free nitrogen by the growth of the Leguminosæ under the influence of microbe seeding of the soil, and the resulting nodule formation on the roots, may be considered as fully established.

It is thus seen that the excess of nitrogen cannot be explained by any of the commonly received theories of vegetable physiology we have in outline explained, and also that the importance of this source of nitrogen cannot be overestimated from an economical point of view. It would take us beyond the limits of our space to give in anything like an intelligible manner the life-history of the organism to whose growth the formation of these nodules is due. Next month we shall give in detail the facts so far as known, and illustrate these with reproductions from the original drawings of Prof. Marshall Ward, who has fully worked out the subject.

In the meantime we would briefly call attention to the important practical bearing of the facts known in connection with the formation of these tubercles. Two or three years ago, Prof. Vines, in a paper in the *Annals of Botany*, gave some statistics embodying the results of experiments undertaken to show the influence of the chemical character of the surroundings on tubercle formation. From these it appears that if there is a copious supply of nitrogen in the form of soluble salts, no tubercles, or at least only a few, are formed. And Lawes and Gilbert state, in the paper already referred to, that the evidence of experiments seems to indicate that there is a less development of nodules when the soil is rich in combined nitrogen; while Hellriegel, who agrees that leguminous plants do make use of soil nitrogen, considers that by the aid of the tubercle-forming organisms they draw upon the free nitrogen supplied by the air, and that the formation of the tubercles is, within certain limits, inversely proportional to the supply of combined nitrogen in the soil. It appears that something like this at least is the case, and we can at once see how important is a knowledge of the process going on from an agricultural point of view. At present agriculture in England is in a precarious condition, in which any knowledge which may lead to an economy in the supply of manure will be welcomed. The most expensive manures are generally those containing nitrogen, manures such as nitrate of soda and farmyard manure. The latter, however, contains only a small percentage of nitrogen in a readily available form. Heavy clay soils and very porous soils would not be much benefited by the application of artificial nitrogenous manures, as they require that added, which will make the one less and the other more tenacious in character. But although farmyard manure is cheap in itself, yet the cost of putting it on the soil is considerable, especially if a large area has to be treated; but in such cases the growth of leguminous crops may be resorted to. To quote from the *Gardeners' Chronicle* of 7th May, 1892:—

"In our own country Mr. Mason, of Eynsham Hall, Oxfordshire . . . has devoted about two hundred acres to the practical application of the recently-acquired knowledge in regard to nitrogen fixation. Stated in a few words, this idea is to reduce the area under roots and to grow instead mixed crops of Leguminosæ—beans, various clovers, &c.—liberally manured with basic slag and kainit (manures which contain phosphorus and potassium especially) and

XUM

to convert the produce in the first year into silage, and in the second into hay. The land is thus occupied for two years, and the assumption is that in this way highly nitrogenous crops will be obtained with mineral, but without the highly-expensive nitrogenous manures, and that the land will be left in high condition for the growth of saleable crops, such as potatoes or grain, which require nitrogenous manuring. In other words, the plan is to grow nitrogen-accumulating crops for home consumption, and afterwards nitrogen-consuming crops for sale."

THE FACE OF THE SKY FOR MARCH.

By Herbert Sadler, F.R.A.S.

SUNSPOTS show but little, if any, diminution in number. The zodiacal light should be looked for after sunset in the west, during the absence of the Moon. A conveniently observable minimum of Algol occurs at 9h. 24m. P.M. on the 17th.

Mercury may be observed as an evening star during the first week of the month. On the 1st he sets at 7h. 21m. P.M., or 1h. 44m. after the Sun, with a northern declination of 1° 26′, and an apparent diameter of 8″, about $\frac{3}{10}$ths of the disc being illuminated. On the 8th he sets at 7h. 0m. P.M., or 1h. 10m. after the Sun, with a northern declination of 2° 32′, and an apparent diameter of $9\frac{3}{4}$″, rather less than $\frac{1}{10}$th of the disc being illuminated, and his brightness being about one quarter of what it was on February 18th. After this he approaches the Sun too closely to be visible, coming into inferior conjunction on the 14th. While visible he describes a looped path in Pisces, a little to the east of the 6th magnitude star 22 Piscium.

Venus is a morning star, and is fairly well placed for observation. She rises on the 1st at 5h. 18m. A.M., with a southern declination of 6° 59′, and an apparent diameter of $54\frac{1}{2}$″, $\frac{7}{100}$ths of the disc being illuminated, and the apparent brightness of the planet being about equal to what it was on February 2nd. On the 12th she rises at 4h. 43m. A.M., with a southern declination of 8° 46′, and an apparent diameter of $46\frac{1}{4}$″, $\frac{17}{100}$ths of the disc being illuminated, and the apparent brightness of the planet being about equal to what it was on January 23rd. On the 22nd she rises at 4h. 20m. A.M., with a southern declination of 9° 23′, and an apparent diameter of $49\frac{1}{4}$″, $\frac{3}{4}$ths of the disc being illuminated, and the apparent brightness of the planet (she being now about her greatest brilliancy) being slightly less (in the proportion of 204 to 218) to what it was on January 11th. On the 31st she rises at 4h. 5m. A.M., with a southern declination of 9° 3′, and an apparent diameter of 34″, $\frac{32}{100}$ths of the disc being illuminated, and her brightness being about equal to what it was on January 22nd. During the month she describes a direct path in Aquarius, being about 3° south of the $2\frac{1}{2}$ magnitude star ρ Aquarii on the morning of the 15th, and about 1° south of the 5th magnitude star ξ Aquarii on the morning of the 19th. She does not approach any other naked-eye stars very closely.

Mars is invisible for the observer's purposes.

Pallas (*cf.* "Face of the Sky for February"), is still visible, though she decreases in brightness to the 7th magnitude by the end of the month. On the 1st her R.A. is 9h. $10\frac{1}{2}$m., southern declination 9° 44′. On the 15th her R.A. is 9h. 7m., southern declination 3° 32′. On the 31st her R.A. is 9h. 10m., northern declination 2° 46′. She thus pursues an almost perpendicular path through Hydra, starting from the S.W. of Alphard, and crossing to θ Hydræ. On the last day of the month at transit she will be in the same field of view with the last-named star, 19° of arc following it on almost exactly the same parallel of declination. As the Moon will be absent, this will be a capital opportunity, if the night proves fine, for picking up Pallas, as she transits about 8h. 30m. P.M. A notice of the various measures which have been made of the diameter of this minor planet will be found in "Face of the Sky for April," 1890.

The minor planet Ceres comes into opposition with the Sun on the 7th, at a distance from the earth of about 159 million miles, the planet appearing as a star of the 7th magnitude. On the 1st her R.A. is 11h. $45\frac{1}{2}$ m., northern declination 20° 14′. On the 15th her R.A. is 11h. $33\frac{1}{2}$m., northern declination 21° 32′. On the 31st her R.A. is 11h. 21m., northern declination 22° 7′. At transit on the 5th she will be only about 12′ of arc *s p* the $4\frac{1}{2}$ magnitude star 93 Leonis. During the month she describes a slightly curved retrograde path from a little to the west of this star in the direction of δ Leonis. An account of the various estimations of the dimensions of this minor planet will be found in "Face of the Sky for May," 1890.

The minor planet Vesta, the largest of all the asteroids, comes into opposition with the Sun on the 6th, at a distance from the earth of about 125 millions of miles. She then appears as a $6\frac{1}{2}$ magnitude star, falling to the 7th magnitude by the end of the month. On the 1st her R.A. is 11h. $31\frac{1}{2}$m., northern declination 14° 55′. On the 15th her R.A. is 11h. $18\frac{1}{2}$m., northern declination 16° 41′. On the 31st her R.A. is 11h. $5\frac{1}{2}$m., northern declination 17° 55′. She thus describes a retrograde path in Leo from a point just three degrees almost due west from β, towards δ, being at transit on the 9th just 15′ of arc due north of the $5\frac{1}{2}$ magnitude star 85 Leonis. For measures of the diameter of Vesta, *cf.* "Face of the Sky for January," 1890.

Jupiter, though still the most brilliant object in the evening sky, should be looked for as soon after sunset as possible. He sets on the 1st at 0h. 37m. A.M., with a northern declination of 18° 16′, and an apparent equatorial diameter of 37·2″. On the 15th he sets at 11h. 53m. P.M., with a northern declination of 18° 48′, and an apparent equatorial diameter of $35\frac{5}{4}$″. On the 31st he sets at 11h. 4m. P.M., with a northern declination of 19° 29′, and an apparent equatorial diameter of $34\frac{1}{2}$″. During the month Jupiter pursues a direct path in Taurus, through a region barren of naked-eye stars. At about a quarter past nine P.M. on the 25th a $10\frac{1}{2}$ magnitude star will be about 70″ north of Jupiter; on the evening of the 26th an $8\frac{1}{2}$ magnitude star will be situated about 1′ *n p* the planet, and at about 10h. P.M. on the 30th a $10\frac{1}{2}$ magnitude star will be about $\frac{1}{2}$′ of arc north of Jupiter. The following phenomena of the satellites occur while the planet is more than 8° above and the Sun 8° below the horizon:—On the 1st a transit egress of the third satellite at 8h. 20m. P.M., and a transit ingress of its shadow at 11h. 28m. P.M. On the 2nd a transit ingress of the first satellite at 9h. 27m. P.M., and of its shadow at 10h. 44m. P.M. On the 3rd an occultation disappearance of the first satellite at 6h. 47m. P.M., and its eclipse reappearance at 10h. 14m. 34s. P.M. On the 4th a transit egress of the shadow of the first satellite at 7h. 26m. P.M., and an occultation disappearance of the second satellite at 9h. 3m. P.M. On the 6th a transit egress of the second satellite at 6h. 35m. P.M.; a transit ingress of its shadow at 6h. 40m. P.M., and its transit egress at 9h. 3m. P.M. On the 8th a transit ingress of the third satellite at 10h. 26m. P.M. On the 10th an occultation disappearance of the first satellite at 8h. 46m. P.M. On the 11th a transit ingress of the shadow of the first satellite at 7h. 8m. P.M.; a transit egress of the first

satellite at 8h. 9m. P.M., and of its shadow at 9h. 21m. P.M. On the 12th an eclipse reappearance of the third satellite at 7h. 17m. 59s. P.M. On the 13th a transit ingress of the second satellite at 6h. 54m. P.M., of its shadow at 9h. 18m. P.M., and a transit egress of the satellite at 9h. 20m. P.M. On the 18th a transit ingress of the first satellite at 7h. 54m. P.M., of its shadow at 9h. 4m. P.M., and a transit egress of the satellite at 10h. 8m. P.M. On the 19th an eclipse reappearance of the first satellite at 8h. 34m. 37s. P.M., and an eclipse disappearance of the third satellite at 9h. 30m. 16s. P.M. On the 20th a transit ingress of the second satellite at 9h. 40m. P.M. On the 22nd an eclipse reappearance of the second satellite at 8h. 26m. 5s. P.M. On the 25th a transit ingress of the first satellite at 9h. 54m. P.M. On the 26th an occultation disappearance of the first satellite at 7h. 15m. P.M., and of the third satellite at 9h. 3m. P.M. On the 27th a transit egress of the shadow of the first satellite at 7h. 41m. P.M. The fourth satellite is in inferior conjunction at 3h. 29m. A.M. on the 16th, and at 11h. 18m. P.M. on the 29th; in superior conjunction at 4h. 37m. P.M. on the 4th, and at 0h. 13m. P.M. on the 21st.

Saturn is an evening star, rising on the 1st at 9h. 27m. P.M., with a southern declination of 7° 1′, and an apparent equatorial diameter of 18¼″ (the major axis of the ring system being 42″ in diameter, and the minor 10″). On the 12th he rises at 8h. 41m. P.M., with a southern declination of 6° 46′, and an apparent equatorial diameter of 18·4″ (the major axis of the ring system being 42½″ in diameter, and the minor 10″). On the 31st he rises at 7h. 18m. P.M., with a southern declination of 6° 15′, and an apparent equatorial diameter of 18½″ (the major axis of the ring system being 42¾″ in diameter, and the minor 9¾″). Titan is at his greatest eastern elongation at 4h. P.M. on the 12th; Iapetus at superior conjunction at 4h. A.M. on the 20th; and Titan at greatest elongation at 2h. P.M. on the 28th. Saturn describes a short retrograde path through a very barren region of Virgo.

Uranus is now an evening star, rising on the 1st at 11h. 34m. P.M., with a southern declination of 16° 2′, and an apparent diameter of 3·8″. On the 31st he rises at 9h. 30m. P.M., with a southern declination of 15° 51′. During the month he pursues a short retrograde path in Libra, to the E.N.E. of α^1 α^2 Libræ.

Neptune is still an evening star, but should be looked for as soon after sunset as possible. He souths at 6h. P.M. on the 1st, with a northern declination of 20° 35′, and an apparent diameter of 2·6″. On the 31st he souths at 4h. 3m. P.M., with a northern declination of 20° 40′. During the month he describes a short direct path in Taurus. A map of the small stars near his path will be found in the *English Mechanic* for December 29th, 1893.

There are no very well-marked showers of shooting stars in March.

The Moon is new at 2h. 18m. P.M. on the 7th; enters her first quarter at 6h. 28m. P.M. on the 14th; is full at 2h. 11m. P.M. on the 21st; and enters her last quarter at 8h. 28m. A.M. on the 29th. She is in apogee at 4h. P.M. on the 1st (distance from the earth 251,620 miles), in perigee at 6h. A.M. on the 17th (distance from the earth 229,230 miles), and in apogee at noon on the 29th (distance from the earth 251,130 miles). At 3m. past midnight on the 16th the 6½ magnitude star ω^2 Cancri will be occulted at angle from the north point of 88°, and will reappear at 0h. 37m. A.M. at an angle of 314°. At 4h. 5m. A.M. on the 23rd the 1st magnitude star α Virginis will disappear at an angle of 123°, and reappear at 5h. 16m. A.M. at an angle of 297°. At 1h. 47m. A.M. on the 24th the 6½ magnitude star B.A.C. 4700 will disappear at an angle of 109°, and reappear at 3h. 1m. A.M. at an angle of 318°. At 2h. 32m. A.M. on the 26th the 5th magnitude star 2 Scorpii will disappear at an angle of 125°, and reappear at 3h. 52m. A.M. at an angle of 282°; the 6th magnitude star B.A.C. 5255 will disappear at 2h. 58m. A.M. at an angle of 130°, and reappear at 4h. 17m. A.M. at an angle of 275°; at 3h. 6m. A.M. the 6th magnitude star 3 Scorpii will disappear at an angle of 85°, and reappear at 4h. 19m. A.M. at an angle of 320°. At 2h. 25m. A.M. on the 15th the 5th magnitude star 136 Tauri will make a near approach to the Moon's southern limb, at an angle of 185°, the star being about 2′ away. On the 21st the 3½ magnitude star β Virginis will make a near approach to the Moon's northern limb, at an angle of 29°, the distance being about 2½′.

Chess Column.

By C. D. Locock, B.A.Oxon.

COMMUNICATIONS for this column should be addressed to C. D. Locock, Burwash, Sussex, and posted on or before the 12th of each month.

Solution of Problem No. 9.

Key-move—1. Kt to B5.

If 1. . . . K × P, 2. Q to R2ch.
1. . . . P × Kt, 2. Q to Ktsqch.
1. . . . Kt × P, &c. 2. Kt to Kt5ch.
Dual after 1. . . . P to B5 by 2. Q to Kt7 (Author) or 2. Q to B2ch.

Unfortunately this dual occurs in the main variation. "Chat" alone has discovered the composer's intention.

Solution of Problem No. 10.

Key-move—1. Q to B3.

If 1. . . . K to K5, 2. Kt × BPch.
1. . . . P to QKt5, 2. Q to B3ch.
1. . . . P to KKt5, 2. Kt to B4ch.
1. . . . Kt (Rsq) moves, 2. Kt to B7ch.
1. . . . Kt (Kt6) moves, 2. Q to Q4ch.

CORRECT SOLUTIONS received from the following:—

Seven Points.—Chat.

Six Points.—Kt. J., H. Holmes, Semper, Guy, E. W. Brook, B. G. Laws, A Norseman, A. C. Challenger, J. H. Christie, A. R., L. Bourne, W. T. Hurley.

No. 9 is correctly solved by H. S. Brandreth, and No. 10 by Alpha.

It is satisfactory to find that, in spite of the gaps caused by Nos. 6 and 7, so many solvers are continuing the fight. With the exception that Mr. Adcock apparently retires, and that "Chat" takes the seventh place, the positions of the leading solvers are practically unaltered.

M. Kaizer.—Thanks for the game, which you will find below.

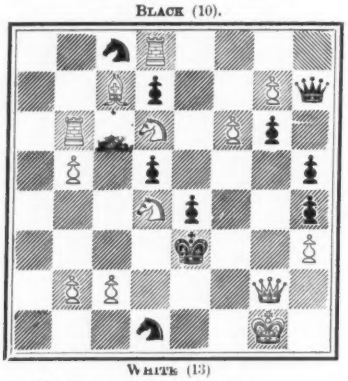
L. Bourne.—We suggested, two months ago, defences to the keys you give for Nos. 4 and 5 (*vide* January number). It is therefore your turn to mate in two moves (if possible) after those defences. If you cannot, the suggested key-moves do not hold good. Black must be allowed to make his best moves.

Semper.—Apart from a curious key and defence to a good "try," we do not remember any particular merit in the problem you mention. Probably many solvers mistook the "try" for the key.

Position No. 11.

"*Pearl of the Garden.*"

Black (10).



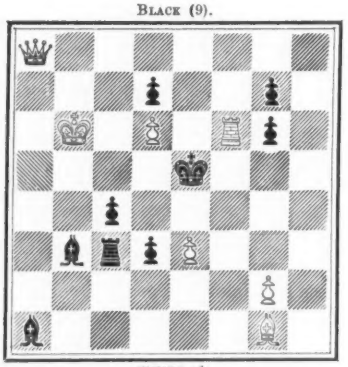
White (13)

White mates in three moves.

Position No. 12.

"*Slender.*"

Black (9).



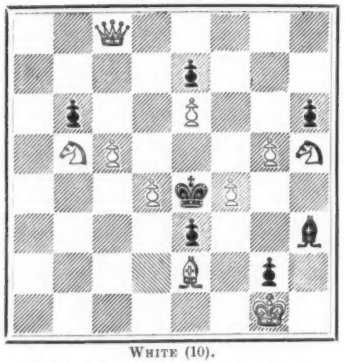
White (7).

White mates in three moves.

Position No. 13.

"*Invicta.*"

Black (7).



White (10).

White mates in three moves.

The following game was recently played in the tournament of the Liverpool Chess Club:—

"Ruy Lopez."

White (M. Kaizer).	Black (F. C. Howard).
1. P to K4	1. P to K3
2. P to Q4	2. P to Q4
3. Kt to QB3	3. Kt to KB3
4. P to K5	4. KKt to Q2
5. P to B4	5. P to QB4
6. P×P	6. Kt to QB3 (*a*)
7. P to QR3 (*b*)	7. B×P
8. Q to Kt4	8. P to KKt3 (*c*)
9. Kt to B3	9. P to QR3
10. B to Q3	10. Q to B2 (*d*)
11. P to KR4	11. P to KR4 (*e*)
12. Q to Kt3	12. Kt to Kt3 ? (*f*)
13. B to Q2	13. Kt to B5 (*g*)
14. B×Kt	14. P×B
15. Kt to K4	15. B to K2
16. Castles (*h*)	16. P to QKt4
17. B to B3	17. Castles (*i*)
18. Kt to B6ch	18. B×Kt
19. P×B	19. B to Kt2 (*j*)
20. Q to Kt5	20. K to R2
21. P to B5 ! (*k*)	21. QR to Qsq
22. P×Pch	22. P×P
23. Q to K3 !	Resigns (*l*)

Notes.

(*a*) The best move, as more than once pointed out in this column. Black reserves the option of capturing the Pawn with either Bishop or Knight, according to circumstances.

(*b*) Some players prefer 7. Kt to B3, or 7. B to K3. The move made compels the capture, and prepares for B to Q3 by preventing Kt to Kt5.

(*c*) Black's play up to the thirteenth move is very weak. He should castle at once, and follow it by the advance of the KBP.

(*d*) Having made his last move he should continue with 10. . . . P to QKt4, with a view to P to Kt5 or Q to Kt3.

(*e*) 10. . . . Kt to Bsq should be better than this.

(*f*) Almost anything would be better, *e.g.*, 12. . . . P to QKt4, or 12. . . . Kt to K2, or 12. . . . B to R2 or K2 with a view to Kt to QB4.

(*g*) And now 13. . . . B to Q2 should have been played.

(*h*) He might have played his next move now, and possibly castled on the other side.

(*i*) Marching straight into the lion's mouth. 17. . . . B to Q2 would enable him to castle on the Queen's side if he castles at all. Probably he feared Kt to Q6ch.

(*j*) There is no time for this. Perhaps his best chance lay in 19. . . . R to Qsq, trying afterwards to bring his Q to KBsq if possible.

(*k*) A pretty finishing touch. White threatens B to Q2.

(*l*) Whether he move the King or not the reply 24. Kt to Kt5 is fatal. Mr. Kaizer played the whole game in good style.

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